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SCIENCE AND THE TREATMENT OF HUMAN AILMENTS.

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In nature, disease and accident give rise to pathologic conditions, or variations from the normal, which are constantly occurring. Any observer of biologic activities must be impressed with the tendency of nature to restore to the normal, variations from the usual growth and development, no matter by what accident or disease these variations have been brought about. In other words, the natural progress of disease, whether occurring in plants, animals, or human beings, is toward recovery. A disease in a human being is known as a human ailment.

The importance of the law of natural progress toward recovery, when applied to the treatment of human ailments, can, with abundant evidence, be esaily proven, since of the ailments of sufficiently incapacitating degree to cause a person to consult one who sets himself up to treat such ailments, eighty-five per cent would progress naturally toward complete recovery. That is, even though the sufferers never sought treatment, eighty-five per cent of these ailments would adjust themselves.

There is nothing in the history of the human race to lead us to believe that the percentage of self-adjusting human ailments was ever less in the past than it is in the present. I lay emphasis on this fact at this point in my discussion of science and its relation to human ailments, so that you may continue to bear in mind the fact that whoever, at any time in human history, has set himself up to treat human ailments always was assured of eighty-five per cent of success, unless the treatment applied was in itself fatal.

Mythology teaches that before the dawn of history, man contended with human ailments, and also that there were those who professed the ability to treat those ailments.

The early history of disease and its treatment was a period of

mysticism, when treatment for prevention and cure consisted of charms and incantations, administered as religious ceremonies. Even yet, among the uncivilized, this same attitude toward human ailments prevails, and to some extent it still permeates civilized people.

The period of mysticism in the treatment of human ailments was followed by a period of theory, when various explanations were offered as the cause of disease. Hippocrates explained disease by the Humoural Theory, according to which the body contained four Humours; blood, phlegna, yellow bile, and black bile, the right proportion and mixture of which constituted health. Another explanation was the Atom Theory of Asclepiades, wherein all diseases depended upon alterations in the size, number, and movement of the atoms of which the body was made up, the proscribed treatment being athletic training.

The third period was one of isolated facts, when those concerned with the treatment of disease began to observe and record for the world, facts relative to human ailments. Outstanding among these recorders was Paracelsus, whose records include reports on the therapeutic value of a number of metallic and vegetable preparations, including tincture of opium to which he gave the name of laudanum. Another outstanding recorder was William Harvey, who discovered the circulation of the blood.

Other important records continued to accumulate in the fields of chemistry and the other natural sciences, until the time of Darwin, Virchow, and Pasteur, which marks the beginning of a fourth period. This was a period of deducing laws from isolated facts, discoveries, and observations. It was the laws formulated by these men and their contempories which constitutes the basis of scientific treatment of human ailments.

Science may be defined as the orderly knowledge of natural phenomena. Medicine may be defined as the theory of the causation of disease, and the science of medicine, as we understand it, has for its province the treatment of disease, or the treatment of human ailments. Since this beginning in the classification of the knowledge of natural phenomena, there has been scarcely a discovery in physics, chemistry, biology, bacteriology, physiology, or anatomy, that has not been of value in developing the fundamental laws of disease and its treatment.

"The science of medicine does not know the name of any school which restricts the activities of investigation."

"The introduction of scientific methods into medicine has

shown that in practically every so-called 'School of Medicine' there is a kernal of truth which may be valuable to the physician, —but which truth, when used beyond its natural limit of application, is reduced to an absurdity. All that is good in all the schools or all the creeds belongs to the school of medicine."

Any school of medicine worthy of the name must recognized the anatomical systems of the body, as they occur embryologically; must recognize the relation of disease to cellular toxins from which develop the principles of sepsis and immunity; must recognize the relation of health to the chemistry of cell metabolism and the multiple stimuli, both physical and chemical, organic and inorganic, which influence cell metabolism. Once these laws have been accepted, understood, and acknowledged, the multitude of facts related to human ailments and their treatment becomes immensely simplified. The person who thus hopes to claim proficiency in the treatment of human ailments has laid a foundation for the utilization of all scientific knowledge in the practice of his profession.

The man in general practice, or the family physician is the one who, above all others, should be schooled in the general sciences, for he must first meet the emergency of sickness and accident. He must decide the seriousness and character of the ailment, and he must decide on the general course of treatment. On him the sick one must depend for advice as to whether or not his illness needs the skill of one trained in a specialty. If the man in general practice does not have the necessary training in science, and for lack of it fails to recognize the seriousness of the condition about which he is consulted, the sick one may, when it is too late, discover that his health has been entrusted to one who is incompetent, and who is unworthy of the trust accorded one who claims knowledge of how to treat human ailments.

When one wishes to confine his activities to a special branch of medicine, he is only justified in so doing after he has received a sufficiently comprehensive education in all branches of science to train him in the classification of the numerous discoveries which the advancing sciences are producing. For, if the specialist fails to recognize and utilize all scientific knowledge related to his specialty, his position becomes one of questionable stability in the scientific world.

The present tendency marks not only a period of specialization in medicine, but a specialization based upon all related scientific

knowledge applied to a limited field. In general, the recognized special fields of medical science are: Internal Medicine; Surgery; Treatment of the Organs of Special Sense; Dentistry; and preventive Medicine.

The man who undertakes to specialize in Internal Medicine, must have received his training in the natural sciences; Must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must become particularly familiar with the more important principles of physiology, chemistry, and biology, as they have to do with cell metabolism and nutrition. He must also be a constant student of pathology and physiology and botany as it relates to pharmacology.

The man who undertakes to specialize in Surgery must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must become particularly familiar with anatomy and many important mechanical principles of physics.

The man who undertakes to limit his work to the treatment of Diseases of the Special Senses, must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must have an intimate knowledge of the minute anatomy of the organs of special sense, and the principles of physics by which they function.

The man who undertakes to specialize in Dentistry must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, and his mechanical skill, he must have an intimate knowledge of the anatomy of the head, and of bacteriology.

The man who undertakes to specialize in Preventive Medicine must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must be a constant student of chemistry, bacteriology, and physics.

Unless the specialist has established in his own mind the relation of his specialty to all the fundamental principles of disease and its treatment, he will not be able to recognize the nature of serious pathology when it presents itself.

When a man sets himself up as proficient in the treatment of disease from the standpoint of a specialist, he must possess familiarity with the natural sciences and the previously mentioned classified studies of scientific medicine. He must possess an attitude of mind which makes him honestly desire a maximum of efficiency in a limited field, for which he will receive compensation in proportion to the art with which he applies this specially acquired knowledge. If he does not possess this broad foundation of the knowledge of the natural sciences; if he is not familiar with the ordered laws of medicine; if he yet holds himself up as a specialist in some department of the treatment of human ailments, then he is not honestly endeavoring to advance the knowledge of disease and its treatment. For treatment, uninspired by scientific understanding of the etiology, or origin and character of the disease in question, is nothing more than an experiment. It is neither necessary nor ethical to experiment on human beings.

The man who so experiments is taking advantage of the public's belief in the specialist for the one and sole purpose of collecting money from that eighty-five per cent of demands made on him for advice in pathological cases and conditions which are naturally self-adjusting. A man with such lack of scruple usually possesses sufficient knowledge of disease to differentiate a part at least, of the cases which require special scientific knowledge for their cure, and he does not attempt to treat cases which require a high degree of skill. His art consists in a diplomacy in ridding himself of those sick who require surgical treatment, who can be benefitted only by the application of a high degree of medical care, or those who would certainly die in spite of any treatment. His education consists rather of studying the patient to determine how he can continue to collect for the given attentions, and how best he can conceal the situation from his patient.

As a rule, the person best fitted for diagnosis and treatment of human ailments promises the least in the way of cure, whereas he who is the least equipped to diagnosis and treat promises the most.

So much for the present-day relation of science to the treatment of human ailments, which we have designated as the Period

of Specialization. From the present tendency one can prophecy that the future will tend toward an even greater specialization.

The future promises to make many new facts available to the physician through the researches in physics and chemistry, particularly colloidal and physical chemistry.

The future science of medicine depends for its progress upon the researches of investigators in the natural sciences, and the future art of medicine depends on the skill with which the physician adopts these discoveries in the prevention and treatment of human ailments. It is this dependence of medical science for its advance by way of researches in the natural sciences that makes it necessary for you who are carrying on these researches to be ever watchful to guide into the study of medicine those who are by education and temperament best fitted to put to practical use these relations of science to medicine.

Thus, when comes to your attention a young man who is a lover of nature; who takes much interest in his studies of physics, chemistry, and biology; who has a natural inclination to mechanics; and who shows more than ordinary powers of deductive reasoning, advise that young man to take up the study of medicine. If he lacks any one of these three qualities, he will not succeed from the standpoint of one who advances the science of medicine, and one who is to be trusted with the treatment of human ailments. Lacking one or more of these qualifications, but possessing a fair knowledge of human psychology, he may succeed, of course, from a financial standpoint.

The responsibility, then, for the future of the medical profession rests as much with the teachers and research workers of the natural sciences as with the medical profession itself.

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A NEW DESIGN OF BOYLE'S LAW APPARATUS AND OF AN APPARATUS FOR THE MEASUREMENT OF THE TEMPERATURE COEFFICIENT OF GASES.

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Boyle's Law Apparatus

A type of Boyle's Law Apparatus which is very comon in Physics laboratories is shown in figure 1. It is made by several different manufacturers and has been used by the author in three or four different colleges and universities. It consists of two glass tubes A and B of the same diameter connected to the flexible tube C by metal connections at J. The tube A is equipped with a stopcock S for the easy filling of the tube or regulating the quantity of air enclosed. A is about 1 cm. in diameter, is graduated to 0.1 cc., and has a maximum capacity of about 25cc. The pressure and volume of the air in A are varied by raising or lowering tube B, and the difference in level of the mercury in A from that in B is obtained by a mirror M with a horizontal scratch and also with a vernier attachment to slide along scale T. The law to be tested is the constancy of the product (PV.) It involves the measurement of the quantities P and V and and an assumption that the mass M of the air in A is constant. Since P and V enter the equation, each to the first power, it is obviously desirable to measure each with approximately the same degree of accuracy, and to be sure of the constancy of M to the same accuracy. If there is any leakage of the air in A our equation becomes

$$k = PV/M \qquad (1)$$

and the fractional error in any particular value of k which the student will have is

$$\triangle k/k = \triangle P/P + \triangle V/V - \triangle M/M \qquad (2)$$

and since $\triangle M$ may be negative as well as positive, the possible error which he may make is

$$\triangle k/k = \triangle P/P + \triangle V/V + \triangle M/M \qquad (3)$$

where $\triangle P$ and $\triangle V$ are errors in reading the pressure and volume and $\triangle M$ is the mass of air which may leak in or out at C or the joint J. P can be measured with an accuracy of 1 or 2 parts in 7,000, but the accuracy of measuring V is only about 1 part in 200 for the smaller volumes. The leakage is often quite appreciable. It seems that this apparatus places entirely too much stress on an accurate measure of the pressure when the inaccuracy of the volume measurement is so large. But the greatest objections to this type of apparatus are: (1) the leaks

both of air and mercury at the joints J, and (2) the dirty tubes due to the mercury running back and forth through the rubber tubing.

Figure 2 shows a type of apparatus designed and built by the author and used in his classes alongside the apparatus described above for comparison. The mercury does not get into the rubber tubing; there is no chance for the mass of the air AB under test to change; and a longer air column is used, thus increasing the accuracy of reading the volume, which in this case is read in centimeters of length instead of cubic centimeters.

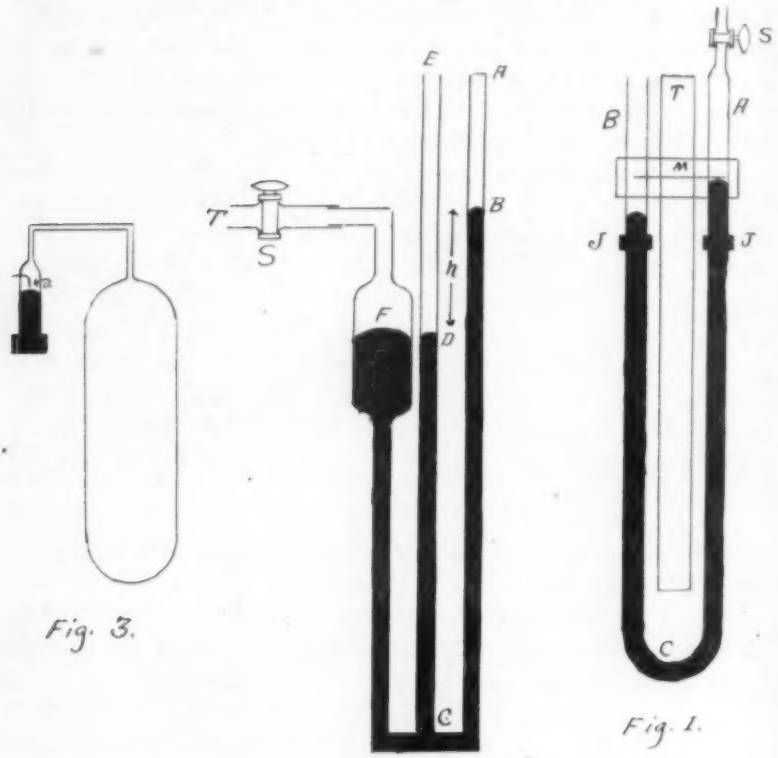

Fig. 3.

Fig. 2.

Fig. 1.

Tubes AC and EC should be the same size to avoid unequal capillary depressions, and AC should have a uniform bore of about 5mm. and a square seal at the top. CE is an open tube which serves as a manometer. The pressure and volume of the air in AB is varied by varying the pressure on the surface of the mercury in reservoir F. This is accomplished by connecting F to an aspirator for lower pressures and to a bicycle or auto pump for higher pressures. F should be of sufficient size (3 or 4 cm. diameter) that fairly large variations in the levels B and

and D will necessitate only a small variation in the level in F. The stopcock S should not be connected to F by a glass connection, for in turning it there would then be considerable danger in breaking the apparatus. It should be noted that a slow leak in S or the rubber tube connections would not be serious as in the apparatus first described, because it would not affect the mass of air under test. Theoretically the height of F is immaterial, but practically it should be of such height that when it is evacuated the mercury level D will be near the bottom of the open tube CE. If F is placed lower, so much pressure is required to force the mercury to the top of the open tube CE that there is danger of the stopcock being blown out and broken or the rubber connection springing a leak. The experiment can be run over quite a wide range using the aspirator only. The difference in level h and the volume AB are read from a meter stick placed between the open and closed manometer arms.

To fill with dry air, close the stopcock and connect E to an air pump and exhaust. Heat the tubes while exhausted to drive off occluded gases and water vapor. Then allow dry air to enter slowly through the stopcock which has been connected to a drying tube. Clean mercury may now be poured in at E, entrapping the dry air in AC. More will usually be entrapped than desired. This can be easily removed by closing E, tilting the apparatus until tube A is somewhat less than 76 cm. higher than C and connecting S to an air pump or the aspirator. As the air is exhausted from F the air in A will expand and be forced out past C and into F until the desire amount of air is left in A.

Referring to equation (3) it will be seen that this apparatus eliminates entirely the error $\triangle M/M$. The volume of air may also be so adjusted that the average value of the errors $\triangle P/P$ and $\triangle V/V$ are equal, a condition which secures the minimum varition of k.

A convenient arrangement is to have the tubes AC and EC about 150 cm. long and the amount of air in AB adjusted until, when EC is half full and E open, AB will be 50 cm. long. If now the stopcock is connected to a good aspirator the level D may be lowered nearly 75 cm. and point B will be lowered about 50 cm. By attaching B to a bicycle pump and increasing the pressure in F to two atmospheres, the level D will be forced to the top of the open tube and the volume reduced to 25 cm. Thus the volume would vary from 25 cm. to 100 cm. while the pressure varied from 4/3 atmospheres to 1/3 of an atmosphere.

If the tube AB is uniform the volume can easily be read with an error of not more than 0.5 mm. and the pressure with an equal accuracy. These two errors combined would give an error in the product less than one-fourth of one per cent. The scale could of course be equipped with a vernier but even without a vernier this apparatus, which can be built at a very small cost, gives results just as accurate as the more expensive apparatus usually used, and, what is more important, it gets rid of the troublesome leaks and dirty tubes.

Temperature Coefficient of Air Apparatus

A common form of apparatus for measuring the temperature coefficient of a gas at constant volume is formed by substituting for tube A (Fig. 1) a bulb E (Fig. 3). Between E and the junction J the capillary tube is enlarged to the same size as tube B to avoid capillary depression, and into it is sealed a platinum wire whose point *a* marks the height of the mercury for constant volume of the enclosed air. This arrangement is subject to the leaky joints at J and dirty mercury in F as in Boyle's Law Apparatus, and in this case it is very much more difficult to clean tube F when it gets dirty. In addition this tube has a fairly large error due to the unheated portion of air in the enlargement F which can be corrected for only approximately, especially as the correction formula commonly used assumes the temperature of the air in F is the same whatever the temperature of the bulb E (See equation 5). In undertaking a modification of this apparatus the author had in mind the reduction of the large quantity of unheated air and the elimination of the leaky joints and dirty mercury.

For this purpose the apparatus as shown in the diagram (Fig. 4) was constructed. Tube LA and the open manometer tube O were cut from the same piece of capillary tubing to avoid unequal capillary depression, and were bent until they were parallel and very close together. The difference in level AB is read on a paper scale mounted behind the tubes. This reduces the volume of the unheated air until the correction due to it is about a fourth of a per cent and the error in the correction is absolutely negligible. The constancy of the volume of air is secured by always bringing the mercury level to point A marked on the tube, and is more accurate than in the old form because an error in estimating the coincidence of the mercury level and point a in the old apparatus would produce 100 times

as much error in volume as a corresponding error in determining the coincidence in the modified apparatus.

Since it is necessary to vary the pressure very slowly in order to keep the mercury level accurately at A, the compression chamber used in the Boyle's Law apparatus was impracticable. Neither was the aspirator suitable because that would necessitate a pressure in E less than atmospheric pressure and great care would have to be exercised to prevent the mercury being forced over into E. Hence the rubber tube D was connected to the manometer tubes by means of the inverted U-tube at C of about 5 mm. bore. The levels A and B are regulated by raising and lowering tube D. The air cushion C, which is easily entrapped by pouring part of the mercury in through D and part through O, transmits the pressure from tube D to bulb E without any mercury ever getting from the rubber tube into the capillaries. D can be moved up and down along any ordinary laboratory standard and held in position by a clamp. It is preferable to have a slow motion screw for adjusting the final height of D, though a small compression clamp on the rubber tube will serve the same purpose fairly well. Filling the bulb with dry air and regulating the amount of air is accomplished by a method similar to that described for the Boyle's Law apparatus. For temperatures from ice to steam a maximum variation of about 30 cm. is all that is necessary for D.

In a particular set of the apparatus the volume of E is 228 cc. and the diameter of the capillary is 2 mm. The length of the exposed air column is 20 cm., giving an unheated volume of 0.6 cc., or only a fourth of a per cent of the whole volume. To give an idea of the magnitude of the corrections, the results for a single trial are given for the measurement of the temperature coefficient β for air at constant volume.

Uncorrected value	β'	= 0.003627
Correction for expansion of glass bulb		= .000031
Correction for unheated portion of air		= .000011
Corrected value	β	= 0.003669

Taking into consideration the possible errors this should be written $\beta = 0.00367 \pm .00001$.

This value of β is calculated from the formulae

$$\beta' = (p - p_0)/p_0 t \tag{4}$$

$$\beta = \beta'\left[1 + \frac{v}{V}\frac{p}{p_0(1+\beta' t')} + \frac{\gamma}{\beta'}\frac{p}{p_0}\right] \tag{5}$$

where p_0 and p are the pressures exerted by the confined air at the temperature of melting ice and the temperature t of steam respectively; v and V are the volumes of the unheated and heated portions of the air and t' the mean temperature of the unheated portion (and since the volume of the unheated portion is so small t' may be taken as room temperature with sufficient accuracy); and γ is the coefficient of cubical expansion of the glass bulb E; $vp/Vp_0(1+\beta' t')$ is the fractional correction for

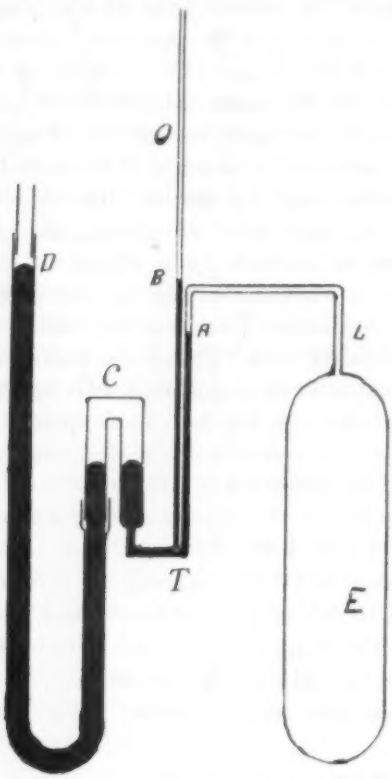

Fig. 4.

the exposed column of air; and $\gamma p/\beta' p_0$ is the fractional correction due to the expansion of the glass. Since these corrections are so small, anything less than a 10% error in them is quite negligible. Hence the principal source of error is in measuring β', and this in turn due to the error in the quantity $(p-p_0)$. The fractional error in p_0 is much smaller due to the fact that it is larger. The error in t, which is really the difference in tem-

perature between melting ice and steam is quite small providing the bulb is left in until the glass and air have had time to come to a state of equilibrium with the ice and the steam. The error in t is much larger when the air thermometer is used to measure the temperature of a liquid where it is difficult to keep the temperature uniform over as large a volume as the bulb occupies and for sufficient time to reach a state of equilibrium. With reasonable care the error in $(p-p_o)$ should not exceed 0.5 mm. which would introduce an error of about 0.2%. All other errors combined should not increase the error in β by more than 0.1%. This apparatus was not perfected in time to be tested in the hands of students, but repeated trials by the author indicated an accuracy of the order indicated. The apparatus can all be mounted on one stand and made quite compact and portable. The total length need not exceed two feet and the quantity of mercury required is small.

SEISMOGRAPH RECORDS FORETELL STORMS

The seismograph, the instrument used to record earthquakes, is also a weather forecaster, and its records may be used to foretell storms, according to Robert W. Sayles, of the Harvard University Museum. This is possible, he says in an article on "Superficial Factors in Earthquake," in "Science," because the reduced air pressure that comes in advance of a storm causes the earth's crust to rise slightly. This tilting is recorded by the motion of the pendulum of the seismograph, and the direction of the tilt shows the direction from which the storm is approaching.

In the opinion of Mr. Sayles, such variations in air pressure, together with deficiency in rainfall, form the most important of the superficial causes of earthquakes. In particular, he has been studying the earthquakes that shook New England last winter.

"According to the data collected at the Blue Hill Meteorological Observatory at Harvard University," says Mr. Sayles, "we had a deficiency of about 8.1 inches of rainfall during the five months previous to March 1, 1925. The quake of January 7 was preceded by three months of very dry weather and immediately followed by rain and a normal rainfall for that month. Then during February there was a deficiency again in rainfall, and then the quake of the 28th, which was likewise followed by rain. Just before this quake, on the 26th, we had the lowest barometric pressure recorded in two years, 28.96 inches at Boston. This low pressure area went northeastwardly and when it reached the Saguenay region, where there is a weak place in the crust, the crust gave way and we had the earthquake. It is true that the lowest pressure had passed on to the east before the shock came, but there is often a lagging effect in earth processes. In my opinion the deficiency in rainfall and the very low pressure acting together was the straw that broke the camel's back."

Mr. Sayles points out that when the barometer goes down one inch, a weight of over a million tons is taken off every square mile of the earth's surface, and a deficiency of eight inches of rainfall over New England would be equivalent to taking nearly forty billion tons off the region. Mr. Sayles also points out that an unusual dry spell proceded the Montana tremblor of June 27.—*Science Service.*

TYPES OF TESTS DESIRABLE FOR CHEMISTRY AND THE PRESENT STATUS OF THEIR DEVELOPMENT.

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A large number of kinds of tests are needed in chemistry to serve various purposes. Persons interested either in standard tests or in chemistry will readily think of many. A few of the types that seem to be especially demanded will be mentioned briefly in this article.

In the first place, there is need for a general survey test in which the status of groups of chemistry students in different stages of advancement may be determined. Much of the work that has already been done in the construction of standard examinations in chemistry is of such a nature that it could be made to contribute materially to this sort of test. Not only is it desirable to survey groups and ascertain their relative standings, but also to get an objective, quantitative measure of the achievment of individuals. For this purpose it is necessary that the general examination be more extensive and inclusive than it need be to get a judgment of group achievement. In the latter instance, some examinees may, by chance, be able to answer more questions of a particular series than they would of another sample of equivalent difficulty for the group; other pupils, in the same examination group, may be able to respond correctly to fewer items of the same series than they would to those of a different sample of apparently similar difficulty. By the laws of chance, if the group be sufficiently large, extreme cases will cancel one another and the average will be a fair representation of the average attainment of the group. The individual, on the other hand, to have his status assessed, needs to be examined by a series of tests, that are equivalent for groups, until the score of a new examination does not significantly change the average of those that have preceded.

In addition to tests of this general type, there are needed others of a more specific nature. Of these, the prognostic test is one that needs to be developed. Boys and girls elect chemistry and are allowed by administrators to take the subject without any effort being made to ascertain their chances of success. At present, the administrator has practically no tools with which to work upon this problem. If he could eliminate at the beginning of the course the students who were certain to make unsatisfactory progress there would be no small saving in time and money.

In New York State from 1896 to 1920, both inclusive, the average percentage of failures in Regents' examinations in chemistry amounted to 27.4%.[1] These students had wasted not only their own time, but a disproportionate amount of their instructors' as well. The well nigh universal testimony of teachers is that they devote most of their time and energy in classroom and in conference to the pupil who is backward in his work; that they let the bright and able pupil shift for himself. It is said that, at one of the large State Universities in the West, the mortality at the end of the first semester of freshman chemistry is fifty per cent. The waste of time and energy by students and instructors when five hundred students are not passed in a half-year's work is tremendous. If one add to the loss of time, the monetary values involved in this loss, the situation becomes still more significant. This financial waste consists in the value of the materials used, of the time that the instructor might have devoted to constructive work, and of the time that the student must devote to completing a substitute for the course that he has failed to pass. A satisfactory prognostic test would help the administrator sort out the potential failures and thus save at least a part of this loss. Such a test for ability in chemistry does not exist. It is needed.

It was pointed out in a previous article[2] that tests to determine the status of an individual at the beginning of a course are desirable. These may well be of at least two kinds. First, in order to determine the advancement that a student makes in the scientific aspects of the subject, it will be helpful to have a test that may be used at the start of a course and again at its close. This would be composed of items with which one might be expected to become familiar as a result of a study of chemistry and not in consequence of the ordinary contacts of daily life.

Second, there is opportunity for a good test based upon common or popular knowledges. This would not be so much a test of information about chemistry, as such, as a test for the backgrounds against which the scientific study could be projected. Such a test might be built, for example, around the common names of substances. In the form of multiple choice questions might be included such items as:

(a) Corrosive sublimate is a compound of COPPER, IRON, MERCURY, ZINC.

[1] Derived from McClelland, W. H., Rural School Survey of New York State, Table 82, p. 533.
[2] SCHOOL SCIENCE AND MATHEMATICS, 25: 157-168.

(b) Epsom salt is named from A MAN, A TOWN, ITS USE, ITS COMPOSITION.

Tests on items of this kind would give a teacher a preliminary knowledge of the general information about chemistry possessed by his students. With this information he could more surely build up his course from the known to the unknown.

Of students destined ultimately to pass the course there are many who have difficulties in mastering some of its elements. Diagnostic tests are needed to help the teacher locate the particular difficulty that the pupil is encountering. It is desirable that a careful analysis be made of the elements contributing to successful performance of every kind of task in chemistry and that a series of tests be then drawn up embracing all these elements from the very simplest to the most complex combination of them. In the matter of equations, for example, analysis might reveal that successful writing of reactions demands a knowledge of symbols, of radicals, of valence; that it requires, further, a clear conception of combination, replacement, double decomposition, and an understanding of oxidation and reduction. If tests to determine the mastery of these different elements were devised it might be possible to locate at once the particular stumbling block of a failing student, help him over his specific difficulty, and clear his path for more successful advancement.

Besides the tests of general achievement there are needed more intensive tests over the constituent parts of the whole. There are needed, for example, tests to determine what a student knows about certain large units in chemistry as the mathematics of chemistry, the phenomena of solutions, the common metals, and the uses of chemicals and chemical processes. There is also a place for smaller testing units based upon the more usual organization of the subject. These would comprise groups of questions on such topics as oxygen, hydrogen, water, and the like.

Not only should there be tests to find out what a student knows, but there should be other tests to determine what he can do. Tests of laboratory skill belong to this category. Likewise, tests of power to deal with familiar material in a new situation are needed, for this ability should be one of the outcomes of chemistry teaching to be especially sought. Such a test, designed for wide use, could be more easily devised if there were a consensus of opinion about what should be taught or a common practice in the teaching. Simply by way of illustration, consider this example. If all teachers taught the preparation of

hydrochloric acid from sodium chloride and sulfuric acid and of chlorine from manganese dioxide and hydrochloric acid but did not teach the preparation of bromine, to ask the student to write one equation showing how to prepare bromine from a source analogous to common salt would be a fair test of his ability. Since, in this particular case, some instructors teach the preparation of chlorine; others, that of bromine; and still others, that of both; it would not be possible to use the suggested question in all classes as a measure of power to deal with familiar materials in a new garb.

An examination of the literature[3] reveals that relatively few attempts have been made to construct tests that meet the needs just specified. Some examinations are designed to serve one specific purpose; others, another. It is probably too much to expect that any one of these early tests or series of tests should meet all the requirements of a comprehensive testing program. They represent, however, the experiments that a few forward-looking individuals have been trying. Many of these experimenters recognize that their attempts are crude and unfinished. They have been willing, nevertheless, as the present writer is glad, to share the results of their thinking and experimenting with their fellow-teachers in the hope that discussion and constructive criticism will lead to the perfecting of more adequate measuring instruments.

PARTIAL, ANNOTATED BIBLIOGRAPHY OF CHEMISTRY TESTS.

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2. BOWSER, J. H., General Chemistry Tests. Distributed by the author from Waynesburg, Pennsylvania. Three tests have been printed. One is concerned with the names of substances that give characteristic reactions; another, with the gases prepared by described methods; the third with the selection of the correct formula for each of a list of twenty-five rather common chemical compounds from a list of five. No results have been published.

3. GERRY, HENRY L., Tests of High School Chemistry. Published by the Harvard University Press, Cambridge, Massachusetts. Two equivalent tests of twenty-five items each, derived by a detailed statistical analysis of questions set by the College Entrance Examination Board during a period of ten years.[5] Test results give high correlation with teachers' grades and with marks on College Entrance Examination Board papers. Norms based on approximately 1500 cases are available.

[3]See Bibliography on this page.

[4]Briggs, Thomas H., Results of the Bell Chemistry Test, Journal of Educational Psychology, 11:224-228 and Gerry, Henry L., Further Data on the Bell Chemistry Test, Journal of Educationl Psychology, 11:398-401.

4. GLENN, EARL R., Unpublished material collected at the Lincoln School, Teachers College, Columbia University, New York City. A thousand or more questions of the types found in standard tests organized around the topics that are usually taught in the secondary school.

5. HAYES, SETH, Cooperative Chemistry Tests. Journal of Educational Research, 4: 109-120. Two tests of twenty questions, selected by a committee of two hundred teachers of Cleveland. Questions are scaled according to difficulty; and weighted scores, derived from probable error values, are assigned each. Mr. Hayes and his committee have prepared four other similar sets of twenty-five items each, selected from about 1200 questions submitted by teachers as important. These four sets have been tried out on about 1500 pupils outside Cleveland but the results have not been published.

6. JONES, FRANKLIN T., The Union Science Tests. Distributed by F. T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio. Ten short tests on some of the important numerical phases of chemistry. Since a time limit is set for each they seem not essentially tests to determine the mastery of facts and principles of chemistry but tests to determine how rapidly students can reproduce symbols, formulas, equations, and the like that they have memorized.

7. POWERS, S. R., The Achievement of High School and Freshman College Students in Chemistry, this Journal, 21: 366-377. Also in A Comparison of the Achievement of High School and University Students in Certain Tasks in Chemistry, Journal of Educational Research, 6: 332-343. Two tests were originally devised: one which required ability to perform the more or less mechanical operations, such as the writing and recognition of formulas and the writing of equations; and another which tested the students' range of informational facts. These have been displaced by revisions, published by the World Book Company.

8. RICH, STEPHEN G., Chemistry Tests. Published by the Public School Publishing Company, Bloomington, Illinois. Two multiple response tests of twenty-five items each constructed on the cyclic principle to measure (a) ability to think, (b) information, (c) ability to solve numerical problems, and (d) habits and knowledge acquired from work in the laboratory.

9. RIVETT, B. J., Testing Results in Chemistry, this Journal, 19: 742-745. Idem, Results with Standard Chemistry Tests, this Journal: 21: 270-272. Three tests, requiring six and one-half minutes, for knowledge of the symbols of the common elements, the valence of the most important elements and radicals, and the ability to write formulas of the most common compounds.

10. RIVETT, B. J., A Comprehensive Chemistry Test, this Journal, 23: 377-386. Two tests: one designed for students at the end of the first half-year of chemistry; the other, for those at the end of the second. Part I consists of problems on hydrogen and oxygen and two general information tests. Part II is made up of problems on volumetric equations a general information test, and one on writing equations. Results of trials with 211 pupils in Northwestern High School, Detroit, are given.

11[1] WEBB, H. A., A Preliminary Test in Chemistry, Journal of Educational Psychology, 10: 36:43. A simple test in the classification of elements, mixtures, and compounds. Used by the author to determine difficulties that need to be clarified in the lecture.

12. WEBB, H. A., Testing Laboratory Resourcefulness, this Journal, 22: 259-266. Dr. Webb suggests in this article some very clever tests of a student's ability to adapt himself to laboratory conditions. They are not standardized.

[1]For method, see Gerry, H. L., A Test of High School Chemistry, Harvard Bulletin in Education, Number IX, Harvard University Press, Cambridge, Massachusetts.

A YEAR IN BIOLOGY II.

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TEACHING HOW TO STUDY

Most of us have had experience at one time or another with lists of study helps that have been given pupils with the very urgent request that they follow them. I remember very well having required that such a list of rules be pasted in the back of the text-book in use. In my judgment, such a procedure was not productive of much good. If good study habits are to be developed, the teacher must have control of the "learning situation" while the training is being given. Under our teaching technique, an ideal opportunity is given for such training in the assimilation period. This period is, for the most part, a work day, period after period, while assimilation of a unit is under way.

The opportunity for training in note taking and in giving attention to a lecture is given in the *presentation*. During the *presentation*, close attention is expected from the entire class. In order to see if the members did get the point in the *presentation* a presentation test was always given. This test usually took the form of a reproduction of the story that had been given by the teacher. The presentation test may take the form of a list of questions covering the main points; true and false test; completion test; or best answer test. This is the teacher's opportunity to "sell" the unit to the class. The presentation, then, must not be a halting affair, but must be an effort on the part of the teacher into which he throws all of his available energy and skill. Training at this point is exceedingly valuable. This is especially true for those who are going to college, where they well need to know how to take lectures notes and write them up.

Tests, both formal and informal, were used to test out the students in each one of the study abilities listed in the first article. This exploration was made at the beginning of the year. It was detailed and thorough. In testing for reading ability the following tests were used: *Thorndike-McCall Reading Scale; Monroe's Standardized Silent Reading Test; and Van Wagenen's Reading Scales.* Thorndike's, *Visual Vocabulary Test,* was also used. Other vocabulary tests modeled after Thorndike's were devised and used. In testing out reading ability for biology material many informal reading tests were devised and used. For teaching purposes, these informal tests are very valuable. In this type of test, a selection of biology

material was given to the class to read. Their rate of reading was determined by having them mark the word that they were on at the end of a minute. Their comprehension was determined by dividing the number of thought units they were able to reproduce after one reading by the entire number of thought units in the selection. This gives a percentage which is sometimes called the *comprehension index*. The results of each test of this kind was shown in either tabular or graphical form. There are a number of other interesting things, aside from rate and comprehension, that can be noted in a test of this kind. The chart may contain such items as *comprehension index*, rate per minute, number of words used to express one idea, orderliness of ideas expressed, tendency to miss ideas at the beginning of the selection, tendency to miss ideas at the end of the selection, tendency to miss ideas in the middle of the selection. Tests will yield their utmost value only when some such detailed analysis of results is employed. And so we might take up each study skill and ability for consideration, if space would permit. Let us consider for a moment the training given in *developing the most effective methods in answering the different types of thought questions.*

Some four years ago, when I was principal of a high school in central Illinois, I was made conscious of the fact that there is a very great variety of types of thought questions, by means of a bulletin that was sent out to the teachers of the state from the Bureau of Educational Research of the University of Illinois. The list was as follows:

1. Selective recall—basis given.
2. Compare two things—on a single designated basis.
3. Compare two things in general.
4. Decision—for or against—choice or preference.
5. Give cause of effects.
6. Explain the use or meaning of some phrase or statement in a passage.
7. Summarize—some unit in the text, article read, or experiment performed.
8. Analysis. (The word itself is seldom involved in the question.)
9. State relationships.
10. Classify. (Usually the converse of 11.)
11. Give illustrations or examples (your own) of principles.
12. Evaluating recall—basis given.
13. Suggest or make applications of rules or principles in new situations.

14. Discuss.

15. Questions of aim—author's purpose in his selection or organization of material.

16. Criticize some statement—as to adequacy, correctness, or relevancy of a printed statement.

17. Give a brief outline.

18. Reorganize facts learned in one organization on a new basis. (A good type of review question to give training in organization.)

19. Questions on new method of procedure.

20. Questions on problems and questions raised. (What questions came to your mind? What else would have to be known in order to understand the matter under consideration? etc.)

From a study of questions in general science, chemistry, and biology text-books and laboratory manuals, it is very evident that even text-book writers in the past have not been conscious of the fact that there are so many different types of thought questions. From one third to one half of all questions in natural science text-books which I have examined have been either pure memory questions or questions involving observation only. Poor answers to thought questions are often due, not to a lack of knowledge of subject matter but to an ignorance of what is involved in a complete answer to a question of a certain type. Now in giving training of this sort, we may follow one of two methods. We may show the students that there are various types of thought questions, comment upon the fact that most people do not know how to go about to give a complete answer to each type, and proceed to show them what the right methods are. In the other method the first thing to do is to give them a problem of one of the various types to answer. This one should be fairly difficult. Most of the students will give a very poor answer. Now without giving any training in subject matter proceed to show them how to break the problem up into sub-questions, to show them how to restate the problem in their own words, and to make them conscious of the type of problem with which they are dealing. After some such mode of procedure the answers that are produced will be so much superior to the first answers that there will be no comparison. After training of this sort, the students will have various samples of the different types of problems in mind and also samples of the best method to follow in solving each type. I have found the second method of procedure very much more effective.

If space would permit, we might take up each study ability and discuss it in some such manner. In dealing with each ability, the first thing was to find out, by the use of tests, to what extent each student had developed the power to use the particular skill or ability under consideration. Group tests were used first. As the problem cases became more and more evident the method of diagnosis and treatment became more and more specific for each problem case. The method of procedure in each case was to *test, diagnose, train; test, diagnose, and train again.*

Handling Test Results.

After a test had been given, it became the teacher's job to get the test papers scored immediately and to devise some sort of tabular or graphical method of effectively representing to the group just how each individual stood with reference to that particular group and also with refernece to a larger group, if the test happened to be standardized. The entire class was always taken into full confidence upon all group tests and every one faced the facts. If this step is rightly conducted, it affords an opportunity to create an entirely new attitude in a class of students toward tests.

Some teachers would proceed as follows: Upon the test that we had yesterday James made a score of 105 and John made only 89. This means that James is intelligent and that John is not. James will likely make quite a name for himself some day. We must push him along rapidly. John will not likely learn much but we shall carry him along and do the best we can for him. What havoc is being wrought by such procedures as the above! Under such handling, James will likely develop into an *intellectual smart-aleck.* He may be bright but the likelihood is that, when his schooling is ended, he will be far from intelligent. John, on the other hand, will be given a sense of inferiority and littleness the overcoming of which will very likely mean the fight of a life time.

The procedure of another teacher will be very different. In the first place, he will have the results of the test thoroughly analyzed. It will not be a matter of intelligence or no intelligence with him but it will be a matter of being able to do or not to do certain specific things. This teacher will proceed some what as follows: The test that we had yesterday is some indication of your ability to do such and such things. James has shown that he can do this, and this, and this, better than John. James is

weak in this particular and needs to learn how to do work of this kind better. John is evidently weak in this, and this, and this. There are good methods to follow in doing work like that required by the test. We are going to find out what those best methods are and then learn to do our work that way. After a while John will very likely be able to pass as good a test as James.

OBJECTIVES OF NATURAL SCIENCE.

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This paper is based upon two general assumptions. The first is that the subject "Natural Science" includes the various branches of Science listed in our school curricula as Nature Study, General Science, Physics, Chemistry, Physiography, Botany, Zoology, Anatomy, Biology, Physiology, and Hygiene.

In order to carry any undertaking to a successful conclusion there must be a definite purpose to impel it onward, and a fixed goal toward which it may be directed. This is as necessary in the case of Natural Science as it is of every other subject in the school curriculum. Yet the following question has never been answered: What will a study of Natural Science contribute to a child's education which he can gain through no other subject now in the curriculum? He is given an education primarily for the purpose of making him a socially efficient being, so we are told, at least to the extent to which this can be done. To accomplish this he must be prepared to care for himself and to do his part in caring for those less able than himself; he must be taught how to live with his fellow-men to their mutual profit; he must be given an appreciation of the good and the beautiful things of life; and in him must be developed a good ethical character. What part of this program can be realized through the study of Natural Science must be determined by the objectives which guide the selection of subject matter and the methods to be used in teaching it. Therefore the second assumption upon which this paper is based is that the general objectives of education should be stated in terms of the general activities of man in living his life.

The general objectives of education have been stated in the following manner: (1) Social Intercommunication; (2) The Development and Maintenance of One's Physical Powers; (3) Unspecialized Practical Labors; (4) The Labors of One's

Calling; (5) The Activities of The Efficient Citizen; (6) Activities Involved in One's General Social Relationships and Behavior; (7) Leisure Occupation, Recreation, Amusements; (8) Development and Maintenance of One's Mental Powers; (9) Religious Activities; (10) Parental Activities, the Upbringing of Children, The Maintenance of the Home Life.[1]

The material for this paper has been derived from three main sources: first, from the courses of study published by various school systems giving space in their science section to statements in regard to the aims or objectives of the different science courses; second, from text-books of the various sciences and from books and magazine articles dealing with the teaching of science; third, from the report of the Commission on the Reorganization of Secondary Education, appointed by the National Education Association, entitled "Reorganization of Science in Secondary Schools" and from the Supplementary Educational Monograph, Number 20, entitled "Curriculum Making in Los Angeles."

Material from the first and second sources is used to depict the past and present prevailing objectives of science education as stated by the present and past science teachers. Material from the third source is used to list the objectives about which the science instruction of the future must be re-organized and which the future science teachers must set up as the goal toward which all their work must point.

By a careful study of the different materials there is found in a few cases a close similarity of objectives and aims, but in many cases there is a very wide divergence. Several typical examples of the statements of objectives of science instruction found in courses of study are quoted at some length.

"The sole purpose of the teaching of hygiene and physiology is to secure the health habits in children themselves. Childhood is the time to learn how to make and to keep the human machine most efficient. Schools are the natural agency for securing health habits because children believe what the teacher says. But the emphasis should always be placed upon the practice by the children, rather than upon knowledge and glibness in reciting the facts as to what shall be done. Knowledge without practice is entirely useless. Instruction in these habits should be based not upon physiology but upon authority. In the intermediate grades, when it becomes advisable to give

[1]Ten Items From "Curriculum Making In Los Angeles," Franklin Bobbitt.

reasons, they should be social and not physiological. For example, in insisting upon mud being cleaned from the shoes before entering the school house, it should be brought out that it is not fair to others to bring mud which will become dust in the room because it effects the lungs of others, especially the weaker child."[2]

"Thus we see that science has as its objectives the health of the child, the formation of the correct habits of health, the living of a healthful life. In addition, through a science course, the child is learning that he has responsibilities in regard to his neighbors. He must not bring mud into the school room because of its effects upon others. Thus he is receiving training for activities involved in his general social relationships.

The civic aim of science instruction is further emphasized by the report of the Kansas State Normal School.[3] "School gardening offers excellent opportunities in civic training. A class in school gardening is a group of boys and girls working together as a community, each child is responsible for his own success and at the same time must help to meet the problems which are of vital importance to the group as a whole. It is the duty of each gardner to keep his patches free from weeds and debris, to allow no weeds which will be disagreeable to his neighbor to go to seed, and to avoid over-reaching the limits of his garden which will mean an encroachment on the public highway. The pupil is trained to put a value on himself and on his work; to recognize the relation between cause and effect; to realize that as a gardener hoes and plants, and weeds, so will he reap.

"Thrift and responsibility are further emphasized in the care of garden implements. Spades, hoes, and rakes not carefully cleaned will rust, thus causing loss of time and unnecessary expenditure of energy in getting them back in working condition. One experience of this kind is usually sufficient to teach a thrifty boy or girl the handicap and actual loss resulting from careless handling or neglect of his tools."

According to this report, in addition to the civic aim of science, provision is made for the unspecialized practical labors of the adult, namely in caring for tools; leisure occupation, in caring for a garden; to a degree the maintenance of one's physical powers through the play-work out of doors.

[2]State Course of Study, State of Michigan, Hygiene and Physiology.
[3]Elementary Course of Study, Kansas State Normal School.

In the elementary course of study of Berkeley, California, the objectives of Nature Study are listed under the following titles, "Health, the Vital Aim," "The Moral Aim," "The Avocational Aim," "Vocational Aim," and the "Civic Aim."

The Vital Aim: Health

In the observation of growing plants and animals in their natural environment, the child is moving about freely in the fresh air and sunshine and becoming healthier and stronger.

In the course of the daily care of pets, in providing them with the proper food and drink and with comfortable, clean quarters in which to live and sleep the child will notice the effects of care and also of the lack of care on the health and happiness of these pets. He will notice, too, how the canary or cat or pet rabbit keep themselves clean; how the bird takes its daily bath, preens its feathers; how the cat licks its fur clean and washes its head and face with its paws. Noticing the habits of cleanliness among animals the child will become interested in his own personal hygiene.

In the fifth and sixth grades, when raising beans, peas, and potatoes, or chickens, rabbits, and pigeons, the child may find them affected by diseases and in attempting to control these will get the first knowledge that certain germs carry diseases and that cleanliness and sanitary conditions help greatly toward avoiding them. A desire will arise to help keep himself and his surroundings clean and sanitary. Later on, when able to take part in civic matters, there will be a better understanding of sanitary and health laws of local health departments and a willingness to follow and perhaps improve them for the good of the community.

The Moral Aim

Through a knowledge of the life of animals and plants, through a knowledge of the powers and forces that control our earth, the sun, moon, and stars, the child is placed in an understanding relation with the natural world about him. When the nasturtiums or the row of beans are not watered during a dry spell and are found withered the next day, when the pet canary or the guinea pig or rabbit has not been fed and watered for a day or two and it is found listless and unhappy, the child will realize that diligence and care and doing the right thing in time is necessary to health and happiness and that carelessness and shiftlessness are wrong and results in unhappiness and sometimes death. The consequence of neglect or wrong doing

will be shown concretely. There will result more sympathy for animals and plants.

There is nothing that shows a child's heedlessness better than careless planting of seeds. If radish seeds are scattered unevenly in the furrow or a few dropped in the space between the rows, the seed will sprout exactly where dropped. Thus the child comes to realize that it is easier to prevent mistakes than to rectify them.

Through possession of a private garden patch or a pen of rabbits or pigeons, the child's sense of ownership is aroused. If some other child should trample the lettuce or pull out a half a dozen tender radishes or onions, in the surprise and disappointment there will come the realization of the respect that each one owes to the property of others. As a result another child's garden patch will not be so easily destroyed.

In employing leisure hours between school dismissal and dinner time, to work among plant or pets, the child will be kept off the street and will avoid getting into mischief in the neighborhood and will be learning lessons in patience, diligence, steadfastness, and thrift.

The Avocational Aim

The child in his observation of plants and animals will consider it play. Later as a man, when his life is full of the problems of our complex living, these experiences of childhood develop into the proper kind of recreation in the out-of-door world. In consequence, he will not be so apt to seek recreation in unnatural, artificial, or unsanitary places of amusement.

The Vocational Aim

In learning how successfully to raise radishes, beans, corn, and potatoes, to raise chickens and rabbits, in keeping a record of expenses and profits, the child is getting such information and is developing the requisite self-confidence, initiative, and ability as are necessary to overcome difficulties that may arise.

Children raising flowers and vegetables, chickens, pigeons, and rabbits may later become gardeners, orchardists, farmers, stockraisers or truck-gardeners. Some may become foresters or expert directors of government agricultural laboratories. Later where necessary small incomes may be supplemented by the raising of plants and animals on the home grounds.

The Civic Aim

In the furthering of food production by school children on

plots of ground considered their own, in the raising of their own chickens and rabbits is aroused a sense of ownership and a knowledge and love for the cultivation of the soil. In the pride that comes for one's very own garden, for one's very own animals, comes a pride in one's own home surroundings, in neighborhood homes, gardens, and animals. This leads in time to improvements in the whole community and to better civic conditions.

"Where agriculture education has been made compulsory in the school of France and Belgium and in certain districts of Illinois and Iowa, the young people are very proud of their homes and their farms, and the movement of population has been from the cities to the country."[4]

Through the efforts required in cultivating and gathering crops through the knowledge gained of the values of their products there will be engendered ideals of thrift and conservation.

The study of the protection of the natural and native wild life of our state parks, the study of the sources of our water supply and their protection, lead to the realization of civic responsibility.

Hodge in his introduction to "Nature Study and Life" expresses the following ideas on civic aims: The highest realization of civic responsibility and assurance of the laws affecting the welfare of the whole community as embodied in the laws and regulations of local boards of health touching on birds, insects, weeds, street trees, forest fires, destructive fungi, and bacterial diseases, these laws express the highest level of intelligent, public knowledge, and opinion. One will obey these laws willingly when he knows the facts on which they are based. Children getting all these facts in the study of nature and elementary agriculture will become intelligent observers and later on intelligent makers of these laws."

The leaders of the Philadelphia School Survey seem to have reached similar conclusions when they state that "the general aims and objectives of science education should be in harmony with and directed toward the realization of the main objectives of secondary education." The seven main objectives of secondary education given in its report entitled "Cardinal Principles of Secondary Education" are Health, Fundamental Processes,

[4]Agricultural Nature Study and School Gardens, James Jewell.

Worthy Home Membership, Vocation, Citizenship, Worthy Use of Leisure, and Ethical Character.[5]

The summary of the aim presented by that group of educators is as follows. In the realization of these objectives no subject in our school program of studies has more to contribute than science.

1. How to keep one's self physically fit, how to promote and maintain the public health are questions which vitally affect the present and future condition of every one and must find an effective answer in the science instruction of every high school.

2. In the teaching of the fundamental processes, such as reading, writing, arithmetic, and elements of oral and written composition, the facts and wonders of science provide inexhaustible and highly motivated material. The fundamental facts and principles of science like those of health affect everyone of us, not merely on certain days of the week for restricted periods but every minute of every day and ought, therefore, to interpenetrate and color the material of instruction in other subjects. The work of science instruction should, therefore, include the effective correlation of the materials of science with the other subjects of the curriculum particularly in the Junior High School.

3. Science has done much within recent years to make home keeping more efficient and therefore to make home life more comfortable and attractive. The high school teacher of science has no more fruitful field of service than in the extension and application of the principles of science to the activities that center around the life and management of the home. These activities have to do not only with problems of sanitation affecting the health of the members of the family but also with devices and methods that make for increased efficiency in the management of the home and for higher standards of human life in the families represented in the school's clientele. To make every pupil an increasingly helpful and worthy member of his home is an important and fundamental objective of science instruction.

4. Science courses organized so as to show the practical applications of the principles of physics, chemistry, and biology to commerce, industry, and the home will provide much valuable basic preparation for life work, particularly of pupils whose formal education may not extend beyond the high school

[5]U. S. Bureau of Education, Bulletin No. 35, 1918.

period. Science instruction should, furthermore, cultivate an intelligent appreciation of the important and indispensable part science plays in the development of both human and material resources of our nation. The natural increase of our population and the rapid exhaustion of our vast virgin resources are bringing us speedily into competition on even terms with other nations, whereas heretofore our comparatively small population and our seemingly limitless supplies of raw materials have given us a dominant though unearned position in the struggle for the world's markets. Science instruction in the high schools can do much to instill into our young citizens, prospective voters, an intelligent conception of the degree of our dependence upon scientific procedures and processes for the maintenance of the integrity of our national ideals and standards of labor and commerce.

5. We call a man a good citizen who shows a disposition to cooperate with his fellow citizens for the welfare of all. The cooperation of such a good citizen, however, becomes of largest value only as he learns how to cooperate effectively. Good citizenship in other words depends for its effective exercise not only upon the good will among members of a community or common-wealth but also upon what Huxley called "Organized Good Sense," by which he means science. A citizen with an intelligent appreciation of the methods and processes of science recognizes in the neighboring swamp a civic problem demanding prompt and effective solution. His ignorant neighbor though well disposed to his fellows, fails to appreciate the true menace of the swamp to the health of the community and is with difficulty, if at all, persuaded to support measures providing the necessary relief. If not a wide knowledge, at least an intelligent appreciation of the procedures and processes of science must obviously be an essential and universal factor in citizenship training, if problems affecting the community welfare are to be recognized by the citizens as such and receive the effective and prompt solution they severally require, whether by individual action or by the action of the community as a whole.

6. No more certain means can be found of developing in pupils permanent and profitable sources of personal enjoyment and culture for a worthy use of leisure than the many pleasurable and useful avocational interests that may be established during school days as a by-product of science instruction.

These avocational science interests will find their most effective and frequent expression probably in after school activities such as are provided by clubs, visits to museums and industrial plants, and excursions to nearby places of natural scientific value; and no teacher who appreciates their motivating influence upon the regular classroom science work, may wisely neglect these avocational interests.

7. Ethical character depends for its progressive development upon sound methods of thinking and is characterized by the quality of "suspended judgment" and an unswerving pursuit of truth. Science instruction provides valuable material and discipline for the development in its devotees of sound methods of thinking and fails in its major purpose if it does not inculcate love of the truth and the habit of suspending judgment on any matter until the pertinent facts are known. Science reveals the existence of certain fundamental biological, social, and ethical laws which we may not with impunity disobey and which not only command us, but teaches us how to lead a life of service to the full limit of our native endowments and circumstances.

I have quoted to some extent the aims and objectives of science instruction from the Report of the Philadelphia School Survey, the Elementary Course of Study of Berkeley, California, and the Elementary Course of Study of the Kansas State Normal School because the objectives as expressed are typical of the objectives held in mind by a few progressive science departments throughout our country. In contrast to this list of objectives is the list given by the courses of study of other school systems and other science teachers. One list is progressive, the other is traditional.

One typical example of the traditional list of objectives is that of the Course of Study for High Schools, State of Kansas.

"The first aim in general science teaching is to develop in the pupils the ability to think clearly and accurately about scientific material. It must go further and create in the pupil the habits of thinking scientifically about the problems of life as they arise either in the class room or outside of it. A secondary aim is that of imparting useful information. For instance it is well that the adult citizen, therefore the pupil, should know that flies are a medium of the transmission of disease. It is certainly the business of the schools in a Republic to supply

its citizens with a common fund of knowledge, scientific information, to which appeal may be made when public questions, either national or local involve science. Those citizens who have been trained to weigh evidence and decide questions on the basis of fact rather than prejudice should form the solid nucleus of our communities."

A second typical example of the traditional list of objectives of science instruction is given by the High School Course of Study of Decatur, Illinois.

"The purpose of science instruction and scientific training may be briefly summarized as follows:

1. To lay a good foundation for the successful pursuit of many industrial activities of life.

2. To make close observers of nature and the many natural phenomena that are continually occurring.

3. To train the student to do clear and accurate thinking, to develop the scientific habit of mind and the habit of suspending judgment until he knows the how and why.

4. To create a desire for original investigations and research, the factors which have been and now are of such inestimable value to mankind."

A similar type of objectives is given in the Elementary Course of Study of Fitchburg, Mass. "Nature Study is a common sense study. It attempts to place the child, through interest, in intelligent touch with the natural objects and processes which surround him. It turns to practical use the curiosity and restless spirit of investigation characteristic of normal healthy childhood. This spirit of inquiry that marks the child's mind is the natural channel through which multitudes of little experiences reach their places in the store house of knowledge. It is the province of nature study to develop and direct this form of interest."

(To be continued in January)

PLATOON PLAN IS MORE WIDELY ACCEPTED.

Ninety-nine cities in 32 States have one or more schools organized according to the work-study-play or platoon plan. Wheeling, W. Va., has nearly completed the erection of a new platoon school building and will start its first platoon school. The platoon form of school organization has just been put into effect in all the grade schools of Ellwood City, Pa. Other cities expecting to organize schools on the work-study-play plan during the coming year are Memphis, Tenn.; Eaton, Ohio; Fairmont, W. Va.; and Waltham, Mass. During the past year the Department of the Interior, Bureau of Education, has received requests from every State in the Union except three for information about the platoon plan.

THE TREND OF GENERAL SCIENCE.

By Benjamin C. Gruenberg,

Managing Director, American Association for Medical Progress; formerly head of Science Department, Julia Richman High School, New York; head of Biology Department, Commercial High School, Brooklyn, N. Y.

and

Frank M. Wheat,

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(*Continued from the November issue*)

Study of Materials Outside of School

Visits during school hours (only)	19
Visits after school hours (only)	19
Visits in both school time and after	19
No visits at all	21
Total	78

4 How many hours are pupils in Gen. Sci. expected to devote to study outside of class, laboratory or project work?

The range of "required" study time is from "none" or "optional" (10 schools), to *two hours per day* (3 schools).

Time Required for "Outside" or "Home" Study

	Not feasible to specify	None or optional	Half hour	Three fourths	One Hour	Two Hours	Total replies
Number of schools	9	10	8	10	36	3	76

The unit of outside study time is for each class recitation rather than for each school day. These returns raise sharply the old question of "home work". If they are representative of actual school practice for all subjects of instruction they would mean that high school boys and girls must work something more than an hour a day for every two "periods" of school assignment. That is, more than half the teachers make assignments or requirements that take three hours in addition to the average of six school periods lasting four and a half hours—a seven and a half hour day, which is unquestionably excessive, for a work day. There are, however, two mitigations: (1) the school day includes time in the assembly, gymnasium, shops, studios, etc.; and (2) the pupils do not, as a rule, comply too conscientiously with our requirements.

5 Are your pupils in Gen. Sci. required to keep note books?

Eighty teachers replied to this question. Sixty-nine require the pupils to keep more or less formal note books; ten require more or less informal written records; and one apparently requires no record whatever of the pupils' "work, or thinking, or study".

Coming to the mechanics of school work, it is evident that the loose-leaf type of notebook is preferred by most teachers, whether they use blank pages or printed forms. There is apparently some ambiguity in the question:

6 For pupils' note-books, do you prefer:
a Blank book.....(1) Bound..... (2) Loose Leaf.....
b Printed instructions combined with blank spaces, forms, etc. (1) Bound..... (2) Loose Leaf.....
c Any special size? (1) approx. 6x9..... (2) approx. 8x10½..... (3) some other size, namely.....?

Parts *a* and *b* were intended to be alternatives or mutually exclusive. In the replies (78 usable) only two teachess clearly indicated that they preferred printed forms, and 46 that they preferred blank pages. Twenty-nine indicated their preference for bound or for loose-leaf books under *both* headings. One teacher likes to use 4″x6″ index cards for the pupils' work records.

Styles of Note Books Preferred

		Loose	Bound
Prefer Blank Pages	46	33	13
Prefer Printed forms	2	1	1
No preference indicated	29	26	3
Total	77		
Prefer Loose Leaf		60	
Prefer bound note books			17

The third part, referring to *size* of paper or note books preferred, shows a tendency to use the larger size. No specification if "some other size" departed more than one-half inch from the suggested measurements.

Preferred Sizes of Notebooks

Approximately 6x9 (6 to 6½ by 8½ to 9)	Approximately 8x10½ (8 to 8½ by 10½ to 11)	Some other size * 8½x6½
6	55	1

*The one return entered entered in the third column gave the perferred dimensions as "8½ x6," which may or may not be intended for a book in which sheets are fastened on the short edge.

Eighteen teachers who answered most of the questions have no preference as to size of note book.

7 Do you prefer to have laboratory (or project) directions (a) as part of the textbook.....? (b) separate from text.....?

Seventy-five teachers expressed a clear preference as between work instructions in the text book and instructions in some separate form.

Form in Which Directions are Preferred

As part of textbook	31 = 40 + %
Separate from text	44 = 59 + %

GROUP D ON TEXT BOOKS

From the replies to several of the earlier questions it may be fairly inferred that no one textbook in general science can be entirely satisfactory to most teachers. Such an inference is confirmed by the more direct information in the present group. It is to the writers a hopeful sign that so many teachers can consider the use of several textbooks simultaneously without manifesting severe nervous symptoms. According to our own observations the distribution of preferences in the first of the following questions would have been radically different as recently as ten years ago.

For convenience the numerical returns are placed immediately after the questions.

1 Do you prefer to use

(a)	*One textbook in the hands of all pupils*	**10**
(b)	*A variety of textbooks in hands of pupils*	**1**
(c)	*A variety of textbooks for reference*	**4**
(d)	*A combination of* (c) *with* (a) *or* (b)	
	(c) *with* (a)	**63**
	(c) *with* (b)	**4**

It is interesting to note that whereas only one teacher would prefer to use a variety of textbooks distributed among the pupils, four would be willing to try this arrangement if additional books were available for reference.

2. In the selection of a general science textbook, do you consider the ideal book to be one that

(a) organizes material around one of the special sciences ***3;***

(b) organizes material around some large civic, vocational, or other specialized interest (e. g., the home, agriculture, the automobile, etc.) ***49;***

(c) frankly selects samples from the special sciences ***26?***

The selection of material is a problem that has aroused considerable controversy and stimulated some thinking. The

earlier textbooks in general science were frankly collections of samples from the special sciences, even when the material was closely related to practical problems or to daily experiences and common appliances.[9] The tendency to find a basis of organization in something nearer to the supposed interests of the pupils shows in the preponderances of opinion in the replies to this question, as well as in the more recently published textbooks. One third of the teachers replying apparently assume that a sampling of the special sciences represents the ideal procedure, although it seems likely that it represents only the teachers' habitual way of thinking about science.

With nearly two thirds voting for an organization of material around "some large interest," we still have the problem of selecting the axis or nucleus for the organization. *This is perhaps the most important single problem in the whole field of science teaching.* Good reasons have been offered for each of the various plans tried; and good results have been obtained with each. We shall probably make greater progress if we accept the implication of the group opinion in principle, without assuming that any one plan is necessarily the "best" for all schools, or all teachers, or all communities or children.

One reply objects to each of the suggested plans of organization but does not offer a fourth alternative.

3. Do you think that the ideal text book should contain
(a) Vocabulary of new terms with each chapter.....;
(b) Glossary of new terms at the end.....;
(c) Definitions or explanations of new terms as they arise in the text, only.....?

The problem of new, technical or difficult words is a continuing one in all teaching. Indeed, the criticism is often made that teaching consists very largely of introducing the student to a vocabulary. Whether we think that this is just as it should be, or merely a necessary evil, every teacher finds that it is a part of the task that cannot be escaped.

There were 77 complete replies. About half the teachers (39) think that suitable definitions or explanations of new terms, as they arise in the text, should be sufficient. Nearly half as many (17) would have new terms explained *before* they are used, in a separate vocabulary unit at the beginning (or end) of each chapter. Six would apparently prefer to avoid inter-

[9] One teacher writes: We made a very exhaustive study of General Science text books, and found that the majority of them taught from 60% to 80% of Physics. They seemed to be an adaptation of the authors' pet ideas rather than textbooks built on the new idea."

ruption of the text by placing explanations of new terms in a glossary at the end of the book.

Fifteen teachers would use two or more methods. Thirteen would still explain words as they arise in the text, and supplement with a glossary at the end (8) or a vocabulary at the beginning (2) or with both (3). Two teachers would avoid text explanations and use both an introductory vocabulary and the glossary at the end.

Preferred Methods for Explanation of New Terms

In text as used	39	
In vocabulary before used	17	
In glossary at end	6	
Total, One explanation only		62
In text and in vocabulary	2	
In text and in glossary	8	
In all three	3	
In vocabulary and glossary	2	
Total, two or more explanations		15
Total replies		77

If we ask whether a single explanation of a new term is to be considered adequate, many teachers are likely to have some doubts. Of course, pupils can be referred to the same explanations or definitions repeatedly. The chief difficulty with a single explanation either in the text or in a separate vocabulary comes from the fact that we often find it desirable to use the chapters in some order other than author's sequence, so that we come across terms that had been disposed of in earlier chapters not yet studied. This suggests the need for a convenient way of locating the definitions, and an alphabetical glossary suggests itself as the logical solution.

The objection to both vocabularies and alphabetical glossaries seems to be in the appearance of attaching excessive importance to definitions. It is difficult and often impossible to give more than a formal definition for a new term detached from its context. The best teaching seeks to develop *concepts* and to furnish useful terms for their manipulation, rather than to present words to which meanings have to be attached. The mechanical arrangement is a temptation to both pupil and teacher to make the memorizing of words and definitions a major purpose.

It is interesting to arrange the returns on this question as follows:

Preferred Methods of Acquainting Pupils With New Terms

Explanation in Text	52
No explanation in Text	25
Study of definitions before use of words	24
No vocabulary in advance of use	53
Glossary for reference	19
No Glossary	58

The obvious value of a glossary as a handy reference to supplement either text explanations or vocabulary definitions would seem to warrant a larger proportion (25%) of favorable replies. The value of this instrument, however, can be adequately supplied by a good index, from which the reader can find the first textual use of the word needed, with a better explanation than can ordinarily be put into a glossary. The preference for a separate vocabulary is almost identical with the objection to text explanations (24 and 25 respectively). The preferred arrangement will probably prove to be *adequate explanations of new terms as they arise, with aid in finding these explanations through the general index.*

4 Do you prefer a Gen. Sci. textbook that has questions at the end of each chapter? Yes..... No.....

(Mark in order of your Valuation, 1, 2, 3.)

(a) If so, should these questions be chiefly

(1) to aid pupils in review.....;

(2) to encourage further investigation.....;

(3) to stimulate thought.....?

The judgment of teachers as to the pedagogical value of questions in the textbook, and as to the relative educational value of different types of questions were sought through this question.

Of 79 teachers, six preferred to have no questions. Six others preferred to have questions in the book, but gave no indication of preference as to the different types of questions suggested. Eight had decided preference as to types of questions, and indicated a first choice but no second or third. These eight are included in the table and account for the failure of all the totals to tally.

Relative Value of Different Types of Text Questions

	First Choice	Second Choice	Third Choice
Review	12 (1)	5	43
Stimulate Investigation	11 (1)	35	14
Stimulate Thought	43 (6)	19	3

Whichever way we read these returns, the judgment of the teachers seems to incline very decidedly toward *thinking* as of greater value than *remembering.* The distinction between encouraging pupils to make further investigations and stimulating them to think appears rather arbitrary, after the questionnaries are returned. It was assumed that some procedure would

lead children to initiate experiments or observations, whereas other procedures would lead to more abstract processes. Both types of result seem to be valued by the teachers above mere "learning," which agrees with the returns on questions *9a* and *9b* of *Group B*.

5 Do you consider it desirable that the Gen. Sci. textbook contain summaries or outlines in connection with each chapter or topic? Yes..... No.....

a If so, should these outlines be designed primarily

(1) as an aid to the student's memory.....;

(2) as a guide to the organization of thought.....?

Educational aims, or at least approvals, are again indicated in the replies to the question regarding summaries or outlines in the textbook. Thirteen teachers do not consider such pedagogical aids desirable; one of these adds, however, *if* we are to have them, they should serve toward organization of thought. Sixty-five teachers (81%) are in favor of organization-of-thought type of summary or outline; one voted for the aid to memory type; and two others want both ends served. There is here the least ambiguous return on matter involving educational purposes, as well as the nearest approach to unanimity.

The Place of Outlines or Summaries in Textbook

Outlines, etc., not desirable	13	....	80
Outlines, etc., desirable	67		
Summaries, etc., to help organize thought		65	
Summaries, etc., to aid memory		1	
Summaries to serve both ends		2	68

6 Do you think that the Gen. Sci. textbook should contain reading references for the pupil? Yes..... No.....

(Number in order of relative value)

a If so, should these references be chiefly

(1) other textbooks.....;

(2) to encyclopedias.....;

(3) to standard reference books of advanced grade..... .....;

(4) to current magazines.....;

(5) to bulletins and pamphlets.....;

(6) to what other material .....?

Reading references in the textbook appear to be of doubtful pedagogical value to five teachers. Sixty-two teachers indicated that they considered references desirable, but only half of these (32) attempted to indicate relative values for more than three or four of the types of references suggested.

Choice in Types of Reading References

Order of choice	First	Second	Third	Fourth	Fifth	Sixth	Total for ea. type
Other textbooks	**15**	5	12	3	8	0	(43)
Encyclopedias	2	4	6	**17**	9	0	(38)
Standard References	**14**	8	4	7	8	1	(41)
Current Magazines	10	**18**	3	5	1	1	(37)
Bulletins & Pamphlets	6	8	**17**	5	5	0	(41)
Other materials	....	....	....	2	1	1	(4)
Total for each rank	(46)	(43)	(42)	(39)	(32)	(3)	

At first glance the preferences seem to be too widely scattered to be significant. A careful examination reveals some practical difficulties in the making of a choice. "Other textbooks" and "standard reference books of advanced grade" have nearly the same number of first choices (15 and 14 respectively) out of a total of 46 first choice. This may mean no more, however, than the greater availability of ths type of material, since 10 out of the remaining first choice and 18 out of the 43 second choices are for references to current magazines. If we combine first and second choices, Magazines lead (28) and Reference books and other textbooks are definitely behind with respectively 22 and 20 votes.

That the choice is largely influenced by the character of available material is strongly indicated by the frequency of third choice (17 out of 42) for bulletins and pamphlets. If we combine the first, second and third choice, Bulletins or pamphlets and magazines with 31 votes each, come very close to other text books with 32 votes; and Reference books of advanced grade fall behind (26).

Encyclopedias, in spite of receiving 17 out of 39 fourth choices, are really the fifth choice for the group as a whole. This is seen if we attempt to simplify the comparison by consolidating the choices for each type of reference material into two groups as in the following table:

Comparison of Primary and Secondary Preferences for Various Types of Reference Material

	First, Second and Third Choices	Fourth Fifth Choices	First and Second Choices	Third, Fourth and Fifth Choices
Textbooks	32	11	20	23
Encyclopedias	12	26	6	32
Standard refs.	26	15	22	19
Magazines	31	6	28	9
Pamphlets	31	10	14	27

In both combinations the ratio of primary choice to secondary choice is lowest of all for encyclopedias. On the other hand, in both combinations the ratio of primary to secondary choice is highest for current magazines.

Considering all the factors involved, it would seem fair to say that the combined judgment of all the teachers who replied to this question is about as follows:

The most useful reference reading for students of general science is found in current magazines. For such reading the textbook can obviously not make specific or detailed provision. Current pamphlets and bulletins come next in value, and these also must be found by the teachers and pupils without much aid from the textbook. Of the bound books miscellaneous textbooks are easiest to use and most often accessible, although standard reference books of higher grade are more useful. Encyclopedias, remaining relatively fixed, furnish a usable makeshift.

Popular science books and special treatises are mentioned as most desirable, but these have the drawbacks of current magazines—they cannot be anticipated by the textbook writer.[10]

The combined judgment of the teachers points to a realization of (1) the need for supplementary text material; (2) the fluid character of scientific knowledge; and (3) the need for systematic help in bringing new material to the attention of teachers and pupils.

7. *To what extent do you consider it desirable for a general science textbook to include historical and biographical information?*

Seventy five teachers replied to this question. One said that the science text should contain no historical or biographical material; one suggested the desirability of a separate book "to humanize the instruction". One half of the 73 teachers (36) think there should be very little of such material; 21 approve of some or considerable; and 16 variously indicate what we have tabulated as "much" historical and biographical information. One "should like to see a General Science textbook prepared *largely* from that standpoint".

The significance of this question should be considered in relation to increasing specialization of our various subjects of instruction and to the increasing complexity of modern life. The "humanizing" of our instruction must mean some process

[10] One teacher writes: "A good source-book and manual in the hands of a good teacher would be better than a textbook . . . If a textbook is used it should raise problems, but not rob the pupil of initiative in experimentation. It should abound in bibliography of all types."

of adding to the pupil's appreciation of human values and human achievement in the subject he studies. There is perhaps sufficient stress upon human values in terms of concrete application to the material comforts and enjoyment; there should be increasing attention to human values in terms of man's conquest through ideas, of man's grasp upon his environment, of his insight into nature, of his own spiritual expansion through intellectual processes. Such appreciation approaches close to the esthetic and is quite as legitimate an object to cultivate as appreciation of music, of art, or of heroism. On the side of achievement it would seem important to humanize our instruction by relating the great discoveries, whether of fact or of method in research, to human beings indomitably searching for something beyond, to human beings in perpetual quest, solving problems by distinctly human method, and constantly opening up new territories for further human conquests. The spirit of pioneering, which we have glorified in our teaching of history and civics, finds a legitimate place as an object of regard and of emulation in the field of the race's intellectual growth.

Whether we should teach facts, principles and methods of science out of one book, and the growth of mankind in pursuit of knowledge through another book, is a practical question that seems to admit of only one answer, once we have made up our minds as to the desirability of "humanizing" our instruction.

8. What do you consider the ideal length of a general science textbook, for a one year course.

(*a*) *Under 250 pp.,*	2
(*b*) *Between 250 and 300 pp.,*	9
(*c*) *Between 300 and 350 pp.,*	9
(*d*) *Between 350 and 400 pp.,*	14
(*e*) *Between 400 and 450 pp.,*	17
(*f*) *Between 450 and 500 pp.,*	11
(*g*) *Between 500 and 600 pp.,*	13

The size of a textbook, like the size of factory-made shoes, is always an arbitrary matter. The *fit* is more or less of a compromise. There is hardly any limit to what a book might contain and still comply with the title; but there is a limit to what can be studed in a specified time, there is a limit to the amount of paper we can get for what we can afford to pay for a book, and there is a limit to the weight a boy or girl should be required to carry in the school bag.

As between the "minimum essentials" to which some teachers would strip the textbook (two prefer under 250 pages) and a comprehensive choice of material with opportunity and stimulus to read more than is "required" (13 teachers prefer books of over 500 pages) the tendency is to choose as a fair compromise a book of something over 400 pages. More than half the teachers would consider a book of 400 pages inadequate; about two-thirds would consider a book of over 450 pages as too bulky, or containing too much unusable material.

GROUP E ON ILLUSTRATIONS

1. For purposes of Gen. Sci. teaching should illustrations tend to be chiefly pictorial.....; or chiefly diagrammatic.....?

Apparently both types of illustrations have a place in the textbook. About one-third (27) of the teachers prefer one kind; the same number prefer the other; and 29 think both are needed.

2. In a Gen. Sci. textbook, do you consider it desirable to have drawings prepared with pains as to artistic quality and finish (as well as to scientific accuracy).....; or do you consider sketchy drawings adequate .....?

As between sketchy drawings and carefully finished illustrations, nearly twice as many consider the latter preferable as consider the former adequate (47 and 24 respectively). Eight teachers consider the artistic quality desirable but the sketchy product adequate. This is not easily interpreted, unless we assume that the question of cost or effort enters into the consideration of these teachers. They may mean "Handsome, carefully executed drawings are nice if we can have them, but the others will do." Yet, if we have a choice, for any legitimate reason, it is certainly within our means to get what is desirable.

3 Do you consider it desirable to have the illustration

(a) be merely an aid to the text.....; or, with its legend,

(b) be a more or less autonomous teaching unit.....?

There is a less pronounced preference as between illustrations intended to support the text and those that are, together with their legends, definite and more or less autonomous teaching units.

Desirable Types of Illustration

Aids to Text	Autonomous Teaching Units	Both
27	40	13

Presumably, "both" is to be read "there is need for both types of illustrations" rather than "illustrations should serve

both purposes." It is significant, however, that so large a proportion of teachers registered a preference for the autonomous type of illustration, since so few of the books available actually contain any considerable number of that class.

Summary

It is possible that the general tendencies summarized below cannot be substantiated from the statistical outcome of the replies to our questions. There is a great deal, however, that must be inferred from fragments that do not lend themselves to precise tabulation and computation; and in general we have no doubt given weight to the more articulate and the more emphatic statements that supplement the merely formal filling of blank spaces. We believe that this summary is a fair statement of the tendencies in General Science as revealed by the material which we have collected.

1. There is a tendency to make General Science a continuous part the curriculum from the lower grades on.
2. There is a tendency to make for science an assured place in the high school, by more schools requiring it and by more pupils selecting it where there is an option.
3. There is a tendency to allot to science more time in the program, where it is already in the curriculum.
4. There is a tendency to grant teachers (or for teachers to take) greater latitude in the choice of materials, with increasing recognition of a large number of legitimate claims upon the content of instruction—pupil's interest as well as our opinion as to his needs, the teacher's interest as well as the opinion of supervisor as to what a syllabus should contain, current developments, local conditions, comprehensive outlook.
5. There is a growing recognition for the need of integrating special subjects of instruction with other experiences and with various of the pupil's problems, as well as recognition of the educational value of home projects and community doings.
6. There is an increasing appreciation of the need for inductive experiences on the part of the pupil, and for scientific methods and ideals on the part of the teacher.
7. There is a reaction again the writing of notes as a purely formal procedure, and a tendency to consider the making of records as an instrument in scientific workmanship.
8. There is a growing flexibility on the part of the teachers in relation to the use of textbooks and other pedagogical aids.
9. There is a growing demand for more comprehensive textbooks, but also for an escape from the special sciences in the lower grades.
10. There is a growing appreciation of the pupil's need of help in forming concepts rather than in learning words; and of the teacher's duty to stimulate thought rather than to assist the memory of the pupil.

"Twenty-six general science textbooks that happen to be at hand show a range (as to number of pages) from 289 to 691. Only one has fewer than 300 pages; four have between 300 and 350; seven, between 351 and 400; four between 401 and 450; three between 451 and 500; five between 501 and 600; two over 600.

NOTE ON THE PHILLIPS SYSTEM OF MULTIPLICATION.

By W. E. Pyke,

The Colorado Agricultural College, Fort Collins, Col.

The article on "A Little Understood Principle in Multiplication" by Ira Hilton Jones and Blanche P. Jones in the January Number of School Science and Mathematics has awakened a great deal of interest. The Phillips System, as it is called, is truly remarkable, and it is indeed odd that the method suggested has not been more generally applied.

The method as suggested in the article is readily applicable to two digit numbers, but for numbers with more than two digits the difficulties increase tremendously due to the grouping of two or more digits in the manner suggested in the article and manipulating them as one digit. If the same method of graphical analysis is applied to the multiplication of these numbers of more than two digits a much simpler method of multiplying large numbers suggests itself.

For instance to multiply 397 by 483, the first operation would be to multiply 97 by 83 by the Phillips method obtaining 8,051 for the product. Next we have the cross product of the hundreds digits with the units digits obtained as in the multiplication of two digit numbers by this method. This gives us 37 which is hundreds. Lastly the cross products of the tens digits and the hundreds digits is obtained and carried into the product of the hundred digits with the hundred digits which yields 180 thousands. The sum of these three products, obtained mentally, gives the total product 191,751.

```
  397
  483
 ----
 8051
   37
180
-----
191,751
```

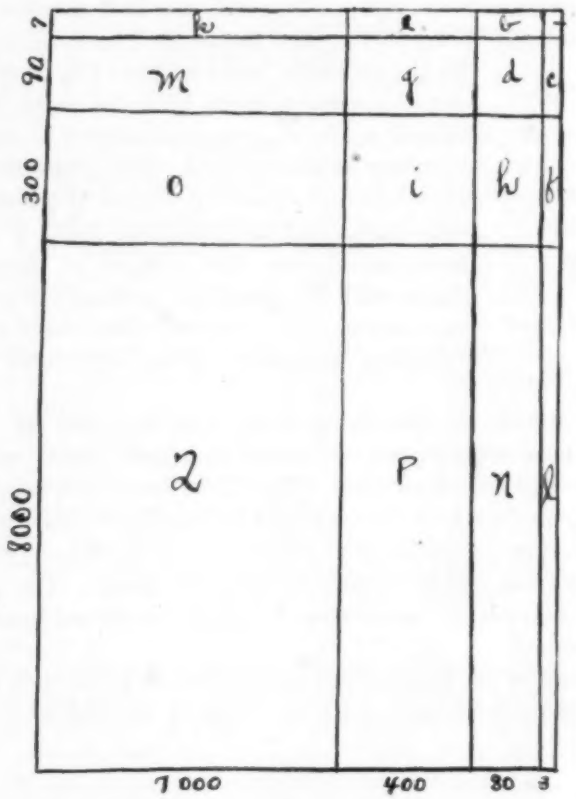
The number of operations is so much less than by the commonly used method and the result can be obtained much more rapidly and with less effort. It will be noted that the product of the tens digit with the tens digit is included in the first product 8,051 and must not be considered again in the cross products or a grave error will be introduced into the result. The same fact must be borne in mind when multiplying larger numbers by this method.

Now allow the numbers considered before to become 8,397 and 7,483 respectively and find the product by the same method.

	8,397
	7,483
I—	8,051
II—	3 7
III—	180
IV—	73
V—	1,27
VI—	61,3
VII—	62,834,751

The operation is identical with the above until we consider the cross products of the units digits and the thousands digits and of the tens digits and the thousands digits which are obtained by the same method as in the above problem, yielding 73 thousands and 127 ten thousands. The next cross product is carried into the product of the thousands digits with the thousands digits, yielding 613 hundred thousands. The sum of these products yields the total product. This same process, which in itself is exceedingly simple, can be applied to numbers containing any number of digits.

The graphical proof is that of the rectangle as explained in the January number.



21—a rectangle
560—b
270—c
7200—d
I— 8091—$a+b+c+d$ rectangle

36000—g
24000—h
120000—i
II— 180000—$g+h+i$

2100000—o
3200000—p
56000000—q
61300000—VI—$o+p+q$

2800—e
900—k
III— 3700—$e+f$

49000—k
24000—l
IV— 73000—$k+l$

630000—m
640000—n
V—1270000—$m+n$

The educational value of finding a practical method for multiplication based upon the rectangle should not be underestimated. When we are able to give children a tangible or graphical proof for a mathematical operation, we are giving them something to which they may tie in their first steps of abstract thinking. In other words we are training them to think mathematically.

Furthermore this method can be easily understood and readily applied. It is much more rapid and practical for every day use than the commonly used method of multiplying for both large and small numbers. It will also be noted that in multiplying these numbers of four digits we have six mathematical operations which are easily performed mentally and that the sum of these numbers obtained in these six mental operations is the product sought, or a product in the ten million column obtained from two four digit numbers is simply the sum of six operations carried on in the mind of the student.

TUBERCULOSIS GERMS IN BOOKS LIVE LONG LIVES.

The best books may be a great source of danger if a careless tubercular person used them last, for Drs. Touchais and Moureau, of Paris, have found that the germs live on the pages for four or five months. The question is regarded as of practical importance because it shows the necessity of disinfecting books circulating in public schools or libraries.

Drs. Touchais and Moureau made tests to see how long the germs from tubercular sputum and from a laboratory culture kept their virulence when smeared on the pages of a large number of books kept in all sorts of conditions such as are found in homes, schools, and libraries. The germs from sputum were the hardiest and were able to infect guinea pigs with the disease even after four and a half months. The germs from the laboratory cultures were still active after two months, but in about three months they were impotent.

THE BALANCE LIKE RENT.

By E. A. Roe

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A discussion of the advantages and disadvantages of the deferred payment or installment plan of financing a purchase, with especial reference to the mthods employed by Building and Loan Associations; together with the derivation of formulas pertaining to the various problems presented.

PROBLEM: A debt is to be paid by a series of equal, periodic payments, each of which is to consist partly of interest on outstanding indebtedness and partly of an installment on the principal. Given all other conditions, what is the amount of the periodic payment?

DISCUSSION: Evidently the periodic payment is the sum of two variables, one increasing and one decreasing. The installments on the principal gradually increase in size and their sum ultimately equals the original indebtedness or principal, while the interest on the unpaid balance of the principal continually declines.

DERIVATION OF THE GENERAL FORMULA:

Let P = the original principal, or debt.
M = the size of the equal, periodic payments.
r = the rate of interest on the unpaid principal.
t = the time, *in years*, between payments.
n = the total number of payments.
$P_1, P_2, P_3, \cdots\cdots P_n$ = the successive, increasing principal payments, whose sum is P.

Then:—

$$P_1 = M - Prt$$

$$\begin{aligned} P_2 &= M - rt(P - P_1) \\ &= M - rt[P - (M - Prt)] \\ &= M - Prt + Mrt - P(rt)^2 \\ &= M(1+rt) - Prt(1+rt) \\ &= (M - Prt)(1+rt) \\ &= P_1(1+rt) \end{aligned}$$

$$\begin{aligned} P_3 &= M - rt[P - (P_1 + P_2)] \\ &= M - rt\{P - (M - Prt) + (M - Prt)(1+rt)\} \\ &= M - rt[P - 2M + 2Prt - Mrt + P(rt)^2] \\ &= M - Prt) + 2Mrt - 2P(rt)^2 + M(rt)^2 - P(rt)^3 \\ &= M(1+rt^2 - Prt(1+rt)^2 \\ &= (M - Prt)(1+rt)^2 \\ &= P_1(1+rt)^2 \end{aligned}$$

Evidently the numbers P_1, P_2, P_3, etc. form a geometric progression, in which the binomial $(1+rt)$ is the constant factor or multiplier. It follows that

$$P_n = P_1(1+rt)^{n-1}$$

By the usual formulas given in the standard texts:—

$$P_1 + P_2 + P_3 + \cdots\cdots P_n = \frac{P_1 - (1+rt)P_n}{1-(1+rt)}$$

But the sum of this series is also equal to P. Therefore:—

$$P = \frac{P_1 - (1+rt)P_n}{1-(1+rt)}$$

Substituting the value of P_n gives:—

$$P=\frac{P_1}{rt}[(1+rt)^n-1]$$

Substituting $(M-Prt)$ for P_1 gives:—

$$P=\frac{(M-Prt)}{rt}[(1+rt)^n-1]$$

Then:—

$$Prt=M[(1+rt)^n-1]]-Prt[(1+rt)^n-1]$$

and:—

$$M=\frac{Prt\{1+[(1+rt)^n-1]\}}{(1+rt)^n-1}$$

$$=\frac{Prt(1+rt)^n}{(1+rt)^n-1} \qquad \text{I}$$

This is the desired general formula, as it gives the value of M in terms of the constants of the problem.

Building and Loan Associations usually base their calculations on $1000 as the unit of indebtedness, and require monthly payments for 120 months. If, then, we assume a special case in which P = $1000, t = 1 month or 1-12 of a year, and n = 120. Formula I becomes:—

$$M=\frac{\frac{1000r}{100\times12}\left(1+\frac{r}{1200}\right)^{120}}{\left(1+\frac{r}{1200}\right)^{120}-1}$$

$$=\frac{5r}{6\left[1-\frac{1}{\left(1+\frac{r}{1200}\right)^{120}}\right]} \qquad \text{II}$$

This gives an equation connecting M and r, from which the monthly payment per thousand dollars of indebtedness can be calculated, with the assistance of logarithms, for any specified rate of interest. Table No. 1 is built up by assigning successive values to r and solving for M.

TABLE NO. I.

Monthly Payments per $1000 of Indebtedness for Various Rates of Interest.

r %	$\frac{r}{1200}$	$\frac{1}{1+\frac{r}{1200}}$	$\frac{1}{\left(1+\frac{r}{1200}\right)^{120}}$	M
0			1.0000	$8.333
4	$\frac{1}{300}$	$\frac{300}{301}$	.66988	10.097
5	$\frac{1}{240}$	$\frac{240}{241}$	.60646	10.588
6	$\frac{1}{200}$	$\frac{200}{201}$	.5490375	11.087

7	$\frac{7}{1200}$	$\frac{1200}{1207}$	.49705	11.598
8	$\frac{1}{150}$	$\frac{150}{151}$	.44999	12.121
9	$\frac{3}{400}$	$\frac{400}{403}$	.40738	12.656
10	$\frac{1}{120}$	$\frac{120}{121}$	.36881	13.202
12	$\frac{1}{100}$	$\frac{100}{101}$	.30311	14.350

By the time the original \$1000 is paid in full, i. e., when 120 payments have been made, the 120M will exceed \$1000 by an amount which is properly called interest, since it is money paid for the use of money. If then, $120M - P$ be regarded as simple interest on a principal P, the *rate* of simple interest may easily be found. Table No. II shows the result of such computation.

TABLE NO. II.

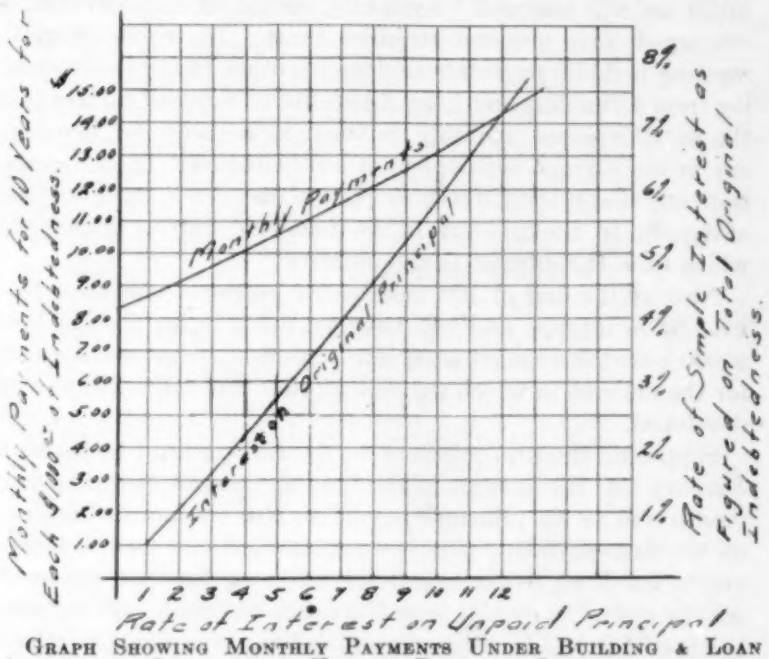
Showing Relation Between Rate of Interest on Unpaid Balance and Rate of Simple Interest Figured on the Original Principal.

r %	120M Total Amount Paid	120M − \$1000 Amount Paid as Interest	Rate at Simple Interest, on \$1000
4	\$1211.64	\$211.64	2.1164%
5	1270.56	270.56	2.7056
6	1330.04	330.04	3.3004
7	1381.76	381.76	3.8176
8	1454.52	454.52	4.5452
9	1518.72	518.72	5.1872
10	1584.24	584.24	5.8424
11			
12	1722.00	722.00	7.2200

The information contained in Tables I and II may be plotted in graphical form. In the first case r should be the independent variable and M the dependent; and in the second case r should again be the independent and the rate of simple interest should be the dependent variable.

From the foregoing it appears that though the rate of interest on the unpaid principal may seem high, the rate, figured as simple interest on the original debt, is much lower. For instance, if the rate of interest specified in the Building and Loan Association contract is 8% the simple interest is but 4.55% per year. How then can the Association pay 6% for the money it borrows and loan it out on these terms? Simple because, by virtue of continued business activity, small principal payments coming in in a

steady stream from clients can very quickly be placed again with new borrowers and the interest-bearing activity of the money is thus very little interrupted. Obviously, it is a matter of indiffer-



GRAPH SHOWING MONTHLY PAYMENTS UNDER BUILDING & LOAN ASSOCIATION CONTRACT AT VARIOUS RATES OF INTEREST, AND ALSO THE CORRESPONDING RATES AS FIGURED ON THE TOTAL ORIGINAL DEBT INSTEAD OF ON THE UNPAID BALANCE.

ence to the company whether client A or client B is paying the interest, and since the actual rate of interest being paid to the company on all outstanding loans is, say 8% or 8½%, the company is in the position of borrowing at 6% and loaning at 8% or 8½% although individual borrowing clients may be paying interest at the rate of only 4.55% to 4.90% per annum on their original indebtedness. The borrower actually pays 8% or 8½% on his unpaid balance but the privilege of continually reducing his indebtedness by small amounts is worth dollars and cents to him and justifies the apparently high interest rate of 8% or 8⅓%.

Suppose, however, that a borrower were able to finance his purchase through an ordinary loan at 4.55% secured by mortgage, and that he should liquidate his debt by creating a sinking fund, making monthly payments to this sinking fund of $8.33⅓ for each $1000 of his debt and setting aside a further $3.78¾

each month to meet his quarterly or semi-annual interest payments. These two sums together total \$12.121, which is what he would have to pay per month to a Building and Loan Association under an 8% contract. Evidently, as far as the borrower is concerned, this program requires exactly the same effort in meeting periodic payments as does the other method of borrowing from a Building and Loan Association. Suppose further that the \$8.33⅓ placed monthly in the sinking fund be invested, say in the savings department of a Building and Loan Association, and that it there draws simple interest at 6% from the date of deposit to the first day of the following July or January at which time the interest is compounded.

Now at the end of 120 months the borrower will have paid \$454.52 in interest and will have available in his sinking fund \$1000 plus the accrued compound interest. A general formula for the amount to which the sinking fund will grow will now be developed.

Supposing the first payment to the sinking fund to be made January 1st, the amount in the fund at the end of the first six month will be six principal payments plus six months' interest on the first payment, plus five months' interest on the second and so on down to one month's interest on the sixth payment. At the end of each half year thereafter the fund will be found to have increased by this same amount, plus six months' interest on whatever was in the fund at the beginning of the half year in question. To adopt a general notation:

Let:—

p = the periodic payment to the sinking fund.
n = the number of these payments between successive compoundings.
N = the total number of times that interest is compounded.
t = the time, in years, between the periodic payments.
T = the time, in years, between successive compoundings.
r = the rate of interest.
A_1 = the amount in the fund at the end of t years.
A_2 = the amount in the fund at the end of $2t$ years.
A_3 = etc.
A_n = the amount at the end of nt years, that is, at the end of T years, since $nt = T$.
S_1 = the amount at the end of T years.
S_2 = the amount at the end of $2T$ years.
S_3 = etc.
S_N = the amount at the end of NT years.
= the final amount of the sinking fund.

Now, at the end of the first time interval, t:—

$$A_1 = p + prt = p(1 + rt)$$

and

$$A_2 = p(1 + rt) + p(1 + 2rt) = p(2 + 3rt)$$
$$A_3 = p(1 + rt) + p(1 + 2rt) + p(1 + 3rt)$$
$$= p(3 + 6rt)$$

Then

$$A_n = p[n + (1+2+3+\cdots\cdots n)rt]$$

$$= p[n + \left(\frac{1+n}{2}\right)(n)rt] \qquad \text{(Since the coefficient of } rt \text{ is an arithmetical progression)}$$

$$= pn\left[1 + \frac{rt(1+n)}{2}\right] \qquad \text{III.}$$

But $n = T/t$. Then:—

$$A_n = p(T/t)\left[1 + rt\left(\frac{1+T/t}{2}\right)\right]$$

$$= p(T/t)\left[1 + r\left(\frac{T+t}{2}\right)\right] \qquad \text{IV.}$$

Furthermore, at the end of the first time interval, T:—

$$S_1 = A_n$$

and

$$S_2 = A_n + S_1(1+rT) = A_n + A_n(1+rT) = A_n[1 + (1+rT)]$$

$$S_3 = A_n + S_2(1+rT) = A_n + A_n[1 + (1+rT)](1+rT)$$

$$= A_n[1 + (1+rT) + (1+rT)^2]$$

Then

$$S_N = A_n[1 + (1+rT) + (1+rT)^2 + \cdots\cdots\cdots (1+rT)^{N-1}]$$

The coefficient of A_n is evidently a geometric progression, and obtaining its sum by the usual formula gives:—

$$S_N = A_n\left[\frac{(1+rT)^N - 1}{1+rT-1}\right] = A_n\left[\frac{(1+rT)^N - 1}{rT}\right] \qquad \text{V.}$$

Substituting the value of A_n from Formula IV gives:—

$$S_N = p(T/t)\left[1 + r\left(\frac{T+t}{2}\right)\right]\left[\frac{(1+rT)^N - 1}{rT}\right] \qquad \text{VI.}$$

This is the desired general formula for the value to which the sinking fund grows. It contemplates $n \times N$ payments of $\$p$, each made at the beginning of a time element t, and with no payment at the end of the last time element t. It also assumes that payments begin at the beginning of a time element T. Clearly, then, the last payment is made t years before the close of the Nth period of T years.

Reverting now to the special case which was being considered, in which

$p = \$8.33\ 1/3$ or $25/3$
$n = 6$
$t = 1/12$ year
$T = \frac{1}{2}$ year $\qquad (T/t = n = 6)$
$N = 20$ (20 half years, equal to 120 months)
$r = 6\%$

Different Building and Loan Associations have different methods of figuring interest on deposits in their savings departments and these methods again change from time to time with varying financial conditions. Usually, deposits credited for less than six months draw no interest, and compounding is accomplished January first and July first on whatever has been in the account all of the preceding half year. In this discussion it is further assumed that if an account be closed between two com-

pounding dates simple interest will be granted on the amount on deposit at the last compounding from that date to the date of withdrawal, but that no interest will be allowed on deposits subsequent to the last compounding. In order that payments to the sinking fund may start on January first it is assumed that the arrangement for financing the purchase in question has been entered into on December first (June first would do as well) since payments to the sinking fund would normally be made at the *end* of each month, rather than the beginning, if they are to correspond to a "Balance Like Rent" plan. The 120th payment would then be made also on a December first and the last six payments would draw no interest. Beginning the payments at any other time would modify the interest returns for the first and last half years of the ten year term.

Substituting the special values given above, in the general formula No. IV, gives:

$$A_n = 25/3(6)\ \frac{[1+(6/100)\frac{1}{2}+1/12]}{2}$$

$$= \frac{407}{8} = \$50.875 \qquad \text{VII.}$$

Of this amount, evidently the fifty dollars is principal and the eighty-seven and a half cents is accrued simple interest.

Substituting now in General Formula No. VI, and bearing in mind that, due to the fact that in the special case the last payment is made just at the close of the transaction instead of t years before the close of the transaction as is contemplated in the general case, N must be taken as 19 instead of 20 and a correction made for subsequent additions to the fund:

$$S_n = \frac{407}{8} \times \frac{(1+6/100\times\frac{1}{2})^{19}-1}{6/100\times\frac{1}{2}}$$

$$= \frac{407}{8} \times \frac{100}{3} \times [(1.03)^{19}-1]$$

$$= \$1278.15$$

To this must be added five months' interest at 6% and also six of the periodic payments of \$8.33⅓ each. The interest amounts to \$31.95 and the payments to \$50.00. The total value of the fund, then, at the end of 120 months, is:

\$1360.10 VIII.

The amount by which this sum exceeds \$1000, namely,

$360.10, may be considered as a refund on the interest previously paid by the borrower in his quarterly or semi-annual payments. That is to say, in the case under consideration, he will have paid in all $454.52 minus $360.10 or $94.42 for the ten years' use of the $1000 or at the rate of less than one percent.

Of course it is not likely that a loan could be secured at 4.55%. But at whatever rate the loan might be made the same $360.10 would be available as a refund on the total interest paid, and would effect a corresponding reduction in the rate. For instance, if the rate of the loan were 6%, the total amount paid as interest would be $600.00 minus $360.10 or $239.90, which corresponds to a rate of about 2.4%. Evidently the nominal rate on the loan is in any case diminished by about 3.6%. This makes it possible to establish a comparison between this method of financing a purchase and the Building and Loan Association plan.

The two plans will be equivalent when the simple interest rate on a straight loan exceeds the simple interest rate as computed on the original principal in the case on the Building and Loan plan by the 3.6%. For example, under an 8% Building and Loan Association contract the simple interest on the original principal is at about 4.55%. If interest must be paid at the rate of 4.55 plus 3.6 or 8.15% on a straight loan the two propositions are equivalent. When the Building and Loan Association payments are $12.30 per month per $1000, as is frequently the case, the rate of interest on the unpaid balance is approximately 8⅓%; the rate at simple interest figured on the original indebtedness is 4⅔%; and the sum of this latter figure and 3.6% is about 8%, the rate at which a borrower could afford to pay on a straight loan. In these two examples it may be noted that an 8% contract is equivalent to 8.15% on an ordinary loan secured by mortgage, and that an 8⅓% contract is equivalent to 8¼% on an ordinary loan, provided in both cases that the borrower can and does establish a sinking fund on which compound interest accumulates as previously described. The values of these rates are so nearly equal that it may be said that in general the rate of interest paid on the unpaid balance under the Building and Loan Association plan is approximately the rate of simple interest which a borrower would pay on an ordinary loan on a financially equivalent plan, assuming, of course, the assistance of the sinking fund. If a loan could be obtained at a lower rate, obviously the advantage would lie with this method in preference to the Building and Loan Association plan.

Again, if the borrower wishes to have the sinking fund amount to exactly the original loan, he may make smaller periodic payments. Then in the special case considered before the final value of the sinking fund will be \$1000 and this will be made up of three things:

(a) 114 monthly payments (19 half-years) with their accrued compoun interest.
(b) Five month's interest on item (a).
(c) The last six monthly payments, without interest.

Then:—

$$\$1000 = S_{19} + .06(5/12) \times S_{19} + 6p \qquad \text{IX.}$$

From General Formula VI we have:—

$$S_{19} = p(6)\left[1 + .06\,\frac{\frac{1}{2}+1/12}{2}\right]\left[\frac{(1+.06\times\frac{1}{2})^{19}-1}{.06\times\frac{1}{2}}\right]$$

$$= 153.378\ p$$

Substituting in IX gives:—

$$1000 = 153.378p + .06x5/12x153.378p + 6p$$
$$= 163.2124\ p$$

And

$$p = \$6.127 \qquad \text{X.}$$

From this it appears that a monthly payment of \$6.127 suitably invested will amortize a \$1000 debt in ten years. Now if an ordinary loan be obtained at, say 6%, the *monthly* simple interest per \$1000 will be \$5.00. If to this be added the \$6.127 the sum will be \$11.127, which may be compared with the \$12.30 more or less per month required under the Building and Loan Association plan, to the obvious disadvantage of the latter. Presumably, if a person were not borrowing from a Loan Association, he would not be interested in the size of their monthly payments and would contribute to his sinking fund in such a manner as to make it exactly amortize his debt in the required time.

In conclusion, then, it may be observed that the Building and Loan Association method of financing the purchase of a home or other property has two distinct advantages; one a business or financial advantage and the other what may be referred to as a moral advantage. The former lies in the fact that the borrower has, and exercises, the privilege of continually decreasing his indebtedness by small amounts, thereby decreasing his total interest payment. The moral advantage consists in the degree of compulsion, under which the borrower lies, to be systematic, to practise thrift, and to meet his payments regularly. On the other hand, the first of these advantages may be negatived by financing the project by the alternative method indicated, and the moral advantage is one which will vary with different indi-

viduals. It appears also that the savings department of a Building and Loan Association may be utilized in the furtherance of a scheme which in some respects is superior to the financial proposition offered by the loan department of the same company.

In general, if a person's spare cash is at all times gainfully employed, either in business or in drawing interest, the privilege of decreasing the outstanding indebtedness by small amounts loses much of its value; and in the case of any given individual, if his small amounts of spare cash are thus gainfully employed, or if he is of a temperament inclined to be far-sighted and systematic in the management of his personal finances the Building and Loan Association plan is not the best; but if his spare cash is not thus gainfully employed, or if he is unlikely to drive himself to the creation of, and the systematic contribution to, a sinking fund then the Building and Loan Associations offer a distinctly attractive and satisfactory proposition.

Dec. 1923.

ALL GEOMETRICAL CONSTRUCTION MAY BE MADE WITH COMPASSES

By Michael Goldberg

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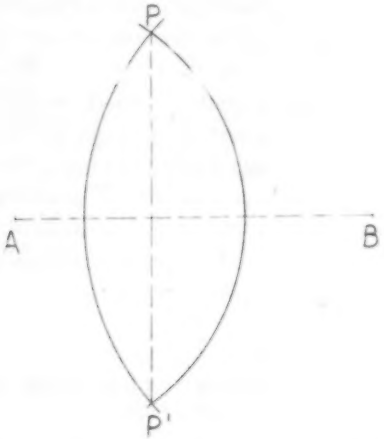
Euclid postulated that "with any center and with any given radius a circle may be described and between any two points a straight line may be drawn." The second of these postulates is not necessary since every geometrical construction can be performed by the compasses alone. All geometrical problems consist in the determination of the position of certain points. A straight line is determined by two points, a circle by its center and a point on its circumference, an angle by its vertex and two points on the two sides of the angle. Points are determined by the intersection of (1) two circles, (2) a straight line and a circle, (3) two straight lines. This paper will show that the second and third cases are reducible to the first, thus eliminating the use of the straight-edge in Euclidean constructions.

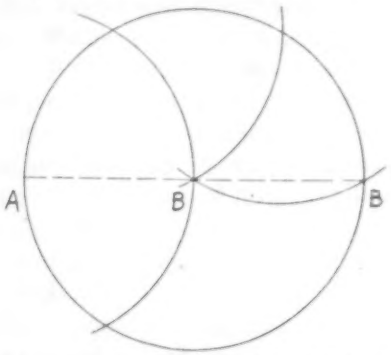
The method employs the transformation known as "inversion with respect to a circle," Let the circle whose center is O and whose radius is r be drawn. Let A be a point outside of the circle. Then the inverse of A with respect to the circle is A′, a point inside the circle and on the line OA such that $OA \times OA' = r^2$. Likewise, A′ is the inverse of A′. It is obvious that if $OB = NOA$, then $OB' = \frac{OA'}{N}$.

The inverse of a point on the circumference is the point itself.

It will be convenient to use A(B) to signify a circle whose center is A and whose radius is AB. Also (AB) will mean the straight line through the points A and B. The following constructions (*a*), (*b*), (*c*), and (*d*) will be used in construction problems.



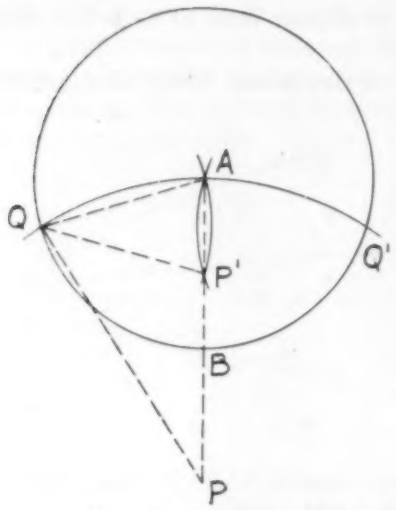
(*a*) Given (AB) and point P. To rotate P about (AB) to P′, draw A(P) and B(P) which will intersect at P′.



(*b*) Given (AB), to find B′ such that AB′ = 2AB draw A(B) and step radius around the circumference three times to B′. This may be repeated as often as necessary in order to obtain *n*AB

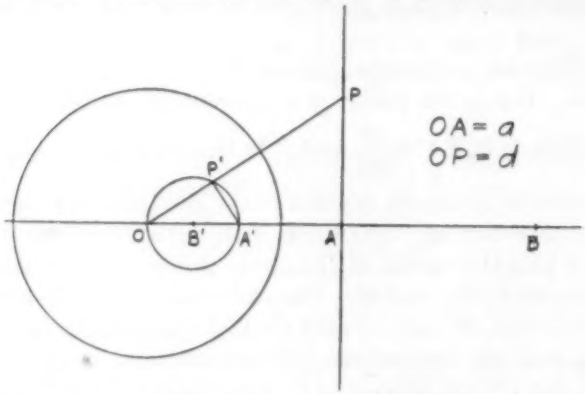
(*c*) To find the inverse of P with respect to circle A(B) draw P(A) intersecting reference circle at Q and Q′. Then P′ is the intersection of Q(A) and Q′(A). This is true because triangles AQP′ and APQ are isosceles and similar and

$$\frac{AP'}{AQ} = \frac{AQ}{AP} \quad AP' \times AP = \overline{AQ}^2 = r^2$$



If P is inside of the reference circle multiply AP by n to bring it outside of the circle and multiply the inverse of nAP by n.

If a straight line be inverted point by point, the inverse will be circle passing through the center of the reference circle. Let the radius of the reference circle be r and the perpendicular distance from its center to the straight line be a. Let P be any point in the line and P′ be its inverse. Draw P′A′ perpendicular to OP′.

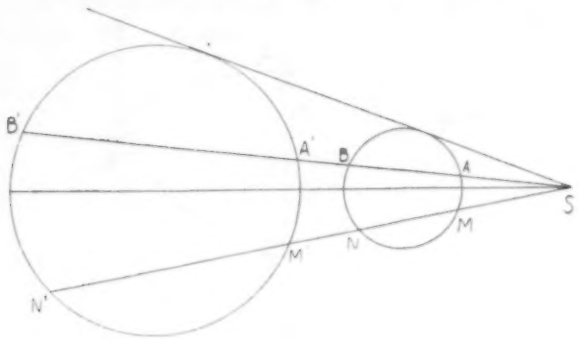


If OP = d and OA′ = a' (See Fig. 1) then $\frac{d}{a} = \frac{a'}{\frac{r^2}{d}}$ since triangles OP′A′ and OAP′ are similar and therefore $a' = \frac{r^2}{a}$ = constant.

Therefore the locus of P′ is a circle since ∠OP′A′ is a right. Note that the inverse (B) of the center (B′) of the circle ob-

tained is twice as distant from O as is the given straight line since $OA' = 2OB'$.

Consider two circles whose center of similitude is S. Draw



any two common secants SABA′B′ and SMNM′N′

Then $\frac{SA}{SA'} = \frac{SB}{SB'} = \frac{SM}{SM'} = \frac{SN}{SN'}$

and $SA \times SB' = SA' \times SB = SM' \times SA' \times SB'$.

But since $SA' \times SB' = SM' \times SN'$ (The product of a secant by its external segment equals the square of the tangent = constant)

$SA \times SB' = SA' \times SB = SM \times SN' = SM' \times SN =$ constant.

Conversely, given any circle A′B′N′M′ and a point S, the locus of such points as A, B, N, and M satisfying the conditions that

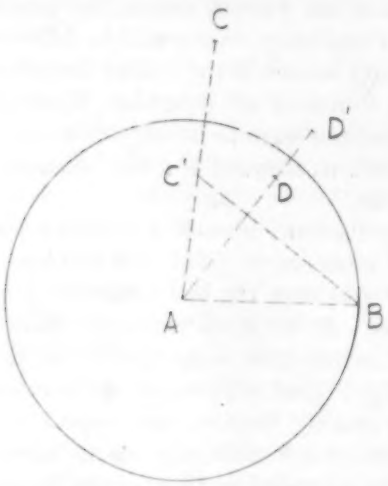
$SA \times SB' = SA' \times SB =$ etc. = constant

is a circle. If S is the center of a reference circle of radius r and the constant is r^2, $SA' = \frac{r^2}{SB}$ and B is the inverse of A′. Therefore, *the inverse of a circle is also a circle* (provided the given circle does not pass through the center of the reference circle.)

(*d*) To find the center of the circle which passes through the given points A, B, and C. Use A(B) as the reference circle. Then the inverse of the required circle is the straight line through B (a point on the circumference of the reference circle is its own inverse) and C′ the inverse of C, (a straight line because point A of the circle is the center of the reference circle) Rotate A about (C′B) to D. Then D′, the inverse of D is the required point (for the inverse of the center of the circle, which is the inverse of a straight line, is twice as distant from the center of the reference circle as is the straight line.

All constructions may now be generalized. To find the inter-

sections of a straight line and a circle, construct any convenient reference circle, and find the inverse circles of the given line and circle. The inverse points of the intersections of the circles are the required itersections. The work is shortened if the given circle is used as the reference circle.



To find the intersection of two straight lines, construct the inverse circles of these lines. The inverse point of the intersection of the circles is the intersection of the straight lines. The center of the reference circle must not lie on the given straight lines for the inverse of a straight line through the center is the same straight line.

NEW METHOD STARVES JERSEY MOSQUITOES.

A new method of exterminating mosquitoes by starvation is being successfully tried in New Jersey. "When mosquitoes are in the wriggler or larval stage," says Dr. Rudolfs of the State Agricultural Experiment Station, "they have jaws and feed on bacteria and other minute forms of vegetable or animal life. By putting chemicals in ponds or creeks this food matter is destroyed and the young starve to death before they have grown their stinging bills. The quantity of chemicals is so small that it will not injure fish or plant life."

New Jersey is the first state to try this method. Dr. Rudolfs is also of the opinion that the dripping of oil and gasoline from motor cars on the roads is helping to kill off mosquitoes.

Dental hygienists are licensed to practice in 21 States, according to a survey conducted by the Interior Department, Bureau of Education, and set forth in School Health Leaflet No. 9; and in other States she may serve as a teacher in oral hygiene. Hospitals, clinics of welfare agencies, industrial and commercial plants, and especially the public schools offer a large field of service for such workers. Ten educational institutions in eight States offer instruction in this department of health preservation.

THE PROBLEM OF SCIENCE TEACHING IN THE SECONDARY SCHOOLS.

R. A. MILLIKAN

Norman Bridge Laboratory of Physics, California Institute of Technology, Cal.

Pasteur, whom the French nation has repeatedly voted the greatest of all Frenchmen, expressed the following judgment:

"In our century science is the soul of the prosperity of nations and the living source of all progress. Undoubtedly the tiring discussions of politics seem to be our guide—empty appearances. What really leads us forward is a few scientific discoveries and their applications."

But possibly Pasteur, himself a scientist, saw his own field a little out of prospective. Let us therefore assign to him a discount value and seek the less naturally biased judgment of a man of letters. H. G. Wells writes as follows:

"When the intellectual history of this time comes to be written, nothing, I think, will stand out more strikingly than the empty gulf in quality between the superb and richly fruitful scientific investigations that are going on, and the general thought of other educated sections of the community. I do not mean that scientific men are, as a whole, a class of supermen, dealing and thinking about everything in a way altogether better than the common run of humanity, but in their field they think and work with an intensity and integrity, a breadth, a boldness, patience, thoroughness, fruitfulness, excepting only a few artists, which puts their work out of all comparison with any other human activity. In these particular directions the human mind has achieved a new and higher quality of attitude and gesture, a veracity, a self detachment, and self-abrogating vigor of criticism that tends to spread out and must ultimately spread to every other human affair."

But Wells has never been famous for his cold, judicial temperament. He has been a man of enthusiasms. Let us therefore assume that he, too, needs to be discounted and consult the philosopher and the educator. In the volume of Herbert Spencer's "Essays on Education"in the Everyman's Series, you will find an introduction by Charles W. Eliot, in which, in reviewing with approval what the great philosopher had to say, he writes:

"Herbert Spencer concluded that for discipline, as well as for guidance, science is of chiefest value. He answers the question,

what knowledge is of most worth? with the one word 'science.' "

But all of these are more or less academic judgments, and the world sometimes refuses to take academic men at their own estimates of themselves. Hence I turn to the latest pamphlet issued by a group of business men and philanthropists, the General Education Board, and find this as the first sentence of the second section:

"The outstanding feature of modern intellectual life is the development of science and scientific method."

Now, if these judgments are all discounted fifty per cent and thus are only half truths, they yet are so significant as to make a consideration of what the secondary school in the United States is doing now to instill the spirit and the method of science into the coming generation as supreme a question as can come before this or any other body of directors of secondary school education.

Unfortunately, I cannot myself approach this theme from the viewpoint of a superintendent. I have never been one. My credentials for discussing it, which I wish to present so that you may make your proper discounts in my case, are only these. My first four years of teaching were spent in conducting classes in elementary physics in the secondary school. For about fifteen years after going to the University of Chicago I assisted in teaching a course in secondary school physics, and in the endeavor to bring about some correlation between high school physics and college physics, a correlation which did not then exist at all and exists only partly now, I became co-author of an elementary text, which has continuously increased in use from the date of its appearance in 1906 up to the present moment, so that I have about me no bitter pill which I have been fletcherizing until I have become a chronic pessimist. This merely to let you know that, if I criticise present tendencies and conditions, it will not be because I have any occasion to be "sore."

Again, I was intimately associated with the initiation of the General Science movement—for which I hope God may some time forgive me—so that I have had to look quite carefully into the teaching of all the secondary school sciences. Further, I taught a course in the pedagogy of secondary school physics for two summers in Columbia University and for ten years in the University of Chicago, indeed, until differences of judgment between myself and the Department of Education caused me to desist. This to let you know that if I should display any dubiousness about courses in education you may realize, first,

that I know from years of observation what the results of some of these courses are, and, second, that this is the one point of tonight's address at which I may be accused in some quarters of having developed a complex which leads me unconsciously to take an unscientific point of view

Finally, for the last dozen years I have been primarily engaged in research work in physics, but have during that time been trying to watch educational movements carefully, especially those relating to the development of the sciences. This, superintendents, is the background from which I address you.

I now wish to set down five conclusions, some of which I shall elaborate, while others need only be stated:

My first conclusion is that we have scarcely begun to touch the possibilities of science instruction in the secondary school as a preparation for rational scientific living and thinking; yet this is a supreme need of America today, and particularly of California where frauds and fads and cults and isms and other evidences of unscientific thinking and living are especially prevalent.

My second conclusion is that, in spite of our failure thus far to solve the problem, its elements are simple and definite; and the mere statement of these elements at once points the way at least to the next steps in the solution.

My third conclusion is that these elements are three in number: The first has to do with the method or technique of teaching a given science in the secondary school. The second has to do with the organization of the curriculum, and with the opportunity and urge which are given to the student to secure the science courses that he needs. The third has to do with the provision of suitable teachers.

My fourth conclusion is that perhaps ninety-five per cent of the effort which has been expended upon this problem thus far has been directed to the first element—the technique of teaching—and it is nearly useless to spend any more time upon it until the second and third elements—as yet almost untouched—have been tackled.

For the successful technique of teaching high school physics, at least, and I think also of other high school sciences, is now pretty well known. I am, of course, not asserting that it is incapable of improvement, and I am very far from asserting that it is always or evenly commonly used. The extent of its use has to do with the third element, the selection and training

of teachers, and about this I shall presently have something to say. But for the last fifty years those who have been actually teaching secondary school physics have been working out by trial and error a successful technique of that teaching, and there is now large agreement upon it. That technique is not obtained, so far as I have ever observed, from courses in methodology in schools of education or teachers' colleges, and that for the very obvious reasons, first, that these courses are rarely taught by men who know from actual experience much about secondary school science teaching, and second, that such courses lack the most vital and essential element of high school teaching, namely, *learning by doing, contact with the presentation of the subject matter itself*. These methodology courses may be enormously valuable for grade teachers. Indeed, it is in the grade teaching that the teachers' colleges have made such contributions as have come from them to American education, for at least in the last forty years during which I have been studying and observing high school science teaching I have seen no appreciable contribution to the development of the successful technique of physics teaching in the secondary school come from any teachers' college. This is altogether natural, for these contributions cannot in the very nature of things be made except by men who themselves understand what science is, what its method is, and what it is doing in modern life, and these men are rare in departments of education. They exist in the scientific departments of our universities, and they exist to some extent in the secondary schools themselves. This is not an unfriendly criticism of schools of education; it is merely an endeavor to point out what progress may be expected from them and what sort may be expected to come from other quarters.

In order to illustrate what an immense amount of effort has been put into the first of my three elements alone and to show the results that may now be obtained by putting a little effort into the second, I should like to review very briefly the General Science movement.

About twenty years ago we science teachers were told by our educational friends, that the trouble with science in the schools was that we were not teaching it rightly, that the smallness of its influence in the curriculum in the schools was due to the fact that we were not making it interesting, that we had it divided into watertight compartments which prevented the student from seeing what it was all about, and we were told that all would be

well if we only set about remedying these defects. I myself never believed that the diagnosis was correct, and I was very skeptical of the suggested remedy because it looked like a pretty thorough disorganizing of what we had spent much time in organizing, but I said deliberately, "Perhaps I am wrong! In any case I am perfectly willing to use the scientific method and to give your proposed remedy a trial," and I assisted in producing one of the early science texts.

It was only when I began to study the high school curriculum for the sake of advising my own boys how to plan their courses that I thought I saw clearly where the real difficulty lay and how simple and obvious was the next step, at least, in its solution. I published my findings in the January 29th, issue, 1916, of "School Science and Society" under the caption "The Elimination of Waste in the Teaching of High School Science," and I am able today to present some just published statistics which bear significantly upon the main point that I therein made, namely, that in high school education, as, indeed, in our advanced education, the supreme question is not what is good and how can we get it in, but how, with the rapid expansion of human knowledge, can we find *time* for that which is absolutely essential? I showed that for students who take the full high school course it is a practical impossibility with the language and mathematics and history and English and manual training which I, as a scientist, want them to take, to get in more than three years of science any way, and that our *whole energies therefore ought to be directed to the arrangement of the curriculum so that we can get as many of the pupils as possible to take three consecutive years of science* and then to pack all the real science that we can into those three years. I showed, as I thought conclusively, that *for pupils who could take those three years* it was a pure waste of time to put one of them into a General Science Course, not merely because they would get the whole content of such a course in the special sciences, and get it in a much better way, but because the special sciences can easily be arranged in such a way as to gain all the advantage that has ever been urged for General Science without the waste of a precious year of time in an already overcrowded curriculum. I quoted the best of educational authority to show that the place of General Science is in the grades. It belongs to the ages ten, eleven, and twelve, and incidentally it seems to me that there is an outstanding opportunity for the development of such a General Science

Course—one altogether unlike the present courses, which are mainly excerpts from the books on the individual sciences. But this is not the subject of my talk tonight.

If General Science is to remain in the high school at all, instead of being pushed over into the grades, it should be largely, if not exclusively, for those who cannot finish the high school course and who therefore have no opportunity to get more and better science. *The exigencies of a high school curriculum do not permit it to be an introduction to a three-year course in the special sciences.*

When ten years ago I showed Professor Otis Caldwell, now of Lincoln School and Columbia University, and one of the authors of a General Science text, my analysis which demonstrated, as I thought, that the only effect upon those taking the full high school course which the introduction into the high school of a General Science course could possibly have would be to substitute General Science for one of the three more valuable courses in the special sciences of biology, physics, or chemistry, his reply was, "Far from it. If I thought that, I myself would be its most deadly enemy. It is rather actually going to stimulate interest in the special sciences and increase their registrations."

He will now be interested, as will you also, in some studies which are presented by Mr. W. R. Leker in the October number of School Science and Mathematics, page 730. These came to my desk only last week. The table from which I quote the following figures is entitled, "The Changes in Science Enrollment in Minnesota for the Five-Year Period from 1915 to 1920." This table shows that the percentage of the total enrollment had changed in these five years as follows: In general science from 1.2% to 11.5%, a gain of 858%; in physics from 10% to 7.8%, or a loss of 22%; in chemistry from 11% to 9.7%, or a loss of 12%; in biology from 1.7% to 1.8%, or a gain of 6%; in zoology from 6% to 2.9%, or a loss of 51%; in botany from 10% to 6.2%, or a loss of 38%; in physiology from 7.5% to 6.3%, or a loss of 16%. The totals in all these courses had changed from 47.4% to 46.2%. These figures, then, show precisely what they were expected to show according to my analysis made in 1915 that there has been no gain in percentage of those taking science —instead a slight loss—while the quality of the science taken has deteriorated, since there has been a gain in the elementary and descriptive and a loss in the more advanced and the more thorough. *General Science has made its large percentage gain of 858% wholly at the expense of the individual sciences.* I have

seen no statistics on this point from other states, but these are surely enough to warrant precisely the opposite conclusion to that drawn by Mr. Leker, and that opposite conclusion is that General Science in the high school should never be a course which is required of all pupils.

I need scarcely say more to show that the problem of secondary school science is exceedingly grave, not because of considerations of *interest* in the subject by the pupils, so far as these figures show, but solely because of the way the high school curriculum has been organized and the way advice from the high school office has been passed on to the students as to the courses in which to register. These two influences are, in my judgment, the chief ones that determine what students take in the high school.

But suppose that all these faults were rectified and that every student who went through the high school took a definite, consecutive, well organized, well taught three-year course in science, such as I am urging that he be given both the opportunity and the advice to take, then how much of the spirit and the method of science which Pasteur and Wells and Spencer and Eliot and Rose feel to be so indispensible to the world's progress would he be likely to get? That brings me to the third element in the problem and to my last conclusion.

My fifth conclusion is that the third element, that having to do with the selection and training of the high school science teacher, has scarcely yet been touched, any more than has the second element, that having to do with the arrangement of the science curriculum. For it is altogether clear that a man cannot inspire in the high school pupil and pass on to him the spirit and the method of science and get him to begin to use it in his daily living unless he himself understands that spirit and himself knows how to use it. Where is that understanding to be obtained? The answer is as obvious and as inevitable as breathing. Not by talking about scientific method, but by getting into close touch with science itself; by *absorbing* its method and its spirit through *actual contact* with it and through *practice* in using it. Where is that contact to be had? Obviously in the great centers of scientific activity of the country; in the graduate schools of science where the prospective teacher can obtain not only a thorough grounding in the fundamentals of mathematics, physics, chemistry, biology and geology, but can also gain some insight into, some little contact with, the method, the spirit, and the significance of scientific research; where he

himself can catch by its use a little of that objectiveness, that integrity, that patience, that thoroughness, that veracity, that self detachment, that discrimination, that self abrogating vigor of criticism which Wells so clearly saw and so eloquently described as the glory of modern science, the cause of its effectiveness and the need of every other human affair.

To illustrate one little element of what I have in mind, I recently heard a professor in one of our best known schools of education tell a class, and then made them tell him, that magnetism was not matter, that it was *energy*. He might quite as well have made them say that a sunbeam was an elephant, for the dimensions of magnetism are not those of energy; it is a different kind of a quantity. It is precisely that sort looseness of thought and speech, that talking without knowledge, that failure to define terms, or to think carefully about their meanings before making assertions, which contact with real science ought to teach one to avoid.

Now, the task and the responsibility of supplying to the secondary school the science teachers who are to lift the whole level of the thought and the life of the next generation because they understand and are imbued to some extent, at least, with the spirit of modern science, that task and that responsibility belong to us who are associated with the graduate centers of science of the country, just as the science curriculum in the schools belongs to you superintendents, and up to the present we have done about as little with our task as you have with yours. Both of us have at this moment an immense opportunity. We scientists can help you a little with advice on your problem—and I could go into definite suggestions as to details if you wanted them—and you superintendents and principals can help us in our work of training future scientists for the secondary schools by removing, or ignoring, or modifying your administrative restrictions and pedagogic requirements which now actually operate, whatever their intent, to divert the best trained and the best qualified young men whom we can turn out, away from the secondary school altogether, indeed, to make it next to impossible for a thoroughly competent teacher of science to now get into the secondary school at all. I am speaking at the moment of conditions existing in this state. I have myself never before met them elsewhere, for in every other part of the country in which I have worked every inducement has been made to draw the best possible material from our University departments of science into the science field of the secondary school. To show

by but one of a number of illustrations which have come to my attention within the past three months, two of them within the past week, precisely what the present situation is, men who have been trained in the scientific center which exists at the California Institute are at this moment being sought by the secondary schools in other parts of the country, but they are actually prevented at present by administrative restrictions from getting into the California schools. One of the finest suburbs of New York sent this summer to the Norman Bridge Laboratory of Physics to obtain a man who had had the training and the contact with modern science which is found there to take an initial salary of $3,600 as the head of the science work in that high school. Fortunately, we had the man and he was at once accepted and has begun his work in New York. This man, with superb qualifications, would have been ineligible in the California schools, while men with one-twentieth of his qualifications for successful science teaching would have been acceptable. Indeed, I do not suppose that one-tenth of our science faculty at the California Institute would be allowed to teach in the public schools of this state. I certainly could not qualify myself. But I suspect that this is merely a local maladjustment to which a satisfactory solution can be found.

That the Institute is alive to its opportunity and its responsibility as an outstanding center of science and scientific progress to do something constructive in the third element is shown by the fact that it has at the moment under discussion in its faculty a special program for the adequate training of the science teacher of the future. That "program contemplates, for the first time in this country," to quote from Dr. Noyes, "the right kind of a course to prepare students for science teaching, for the present university courses are far too superficial on the science side and overdone on the pedagogic side." That program by no means contemplates the training of narrow specialists, but first and foremost it does contemplate the imparting of a thorough familiarity with an understanding of, the fundamental subjects of mathematics, physics, chemistry, geology and biology, and some contact with research work in these fields. But not merely that; it contemplates, also, imparting a contact with the world's best thought through thorough work in literature and philosophy, and an understanding through prolonged study in history, of how man has reached his present stage of development. It involves, also, courses in psychology and ethics, and some few courses, too, in the history of education, such as are now required

by the state law. I am not at all protesting against these latter courses. I am not disposed to discuss the question as to whether they represent one-half of one per cent or two per cent of the necessary educational equipment of the successful teacher. I am merely asserting, and in this I think you will all agree with me, that the secondary school science teacher of the future must be primarily a man who understands science itself and can impart its spirit and its method to those who come in contact with him and thus assist in the supreme task of carrying over that method into the whole of our every day living. When we can find for the secondary schools a man like the one just mentioned who went to New York, the part of wisdom is surely to facilitate in every way his entrance, and then to require him, if you wish, to supplement his already outstanding qualifications by subsequent courses somewhere in educational psychology and the like, but *it is nothing less than suicidal, so far as the development of the science work in the secondary schools of the state is concerned, to put obstacles in the path of his entrance into the school system.*

When you superintendents and principals and we who are responsible for the development of our great graduate centers of science can get to pulling together, we shall be able to push this old world along at a rate heretofore unknown and to do immensely more than we have done so far in causing "the spread of the spirit and the method of science into every other human affair."

PREPARATION OF SALTS.

By John M. Michener,

High School, Wichita, Kansas.

Recently, we received, as an advertisement for a chemistry text, a copy of a chart in the book giving the different methods of preparing salts. We thought that it was a good scheme and we intended to put it on our bulletin board until we discovered that there was not listed all of the methods of which we knew. That set us to wondering if we knew them all, so we began to look through various texts. In no one text did we find all methods given. We have compiled and arranged 19 methods as in the table given hereafter. Have we listed all of the methods? The list is much more complete than any that we have seen before, but there are probably some that we have missed. We have stayed very closely to inorganic chemical methods. If there are any others, we would like to hear of them. The methods are

divided into groups, based upon kinds of chemical change, with sub-divisions, based upon kinds of interacting substances, and examples of each case. More than one example is given in several cases to show the variety that is possible.

Salts are prepared by some one of the following chemical reactions. For any given salt there may be several ways of preparing it. (Actions that can be classified as oxidations or as some other method are put under the latter classification.)

1. COMBINATION.
   a. Metal and a non-metal.
      $Fe + S = FeS$
   b. NH_3 and an acid.
      $NH_3 + HCl = NH_4Cl$
   c. Basic oxide and an acid-anhydride.
      $CaO + CO_2 = CaCO_3$
   d. Salt and an acid.
      $CaCO_3 + H_2CO_3 = Ca(HCO_3)_2$
   e. Salt and a non-metal.
      $Na_2SO_3 + S = Na_2S_2O_3$
      $2\ FeCl_2 + Cl_2 = 2\ FeCl_3$
2. DECOMPOSITION (OF SALTS).
      $K\ CLO_3 = 2\ KCl + 3\ 0_2$
      $Ca(HCO_3)_2 = CaCO_3 + CO_2 + H_2O$
      $FeSAs = FeS + As$
3. DISPLACEMENT. (REPLACEMENT, SUBSTITUTION.)
   a. Metal and an acid.
      $Zn + 2\ HCl = ZnCl_2 + H_2$
   b. Metal and a base.
      $Zn + 2\ NaOH = H_2 + Na_2ZnO_2$
   c. Metal and a salt.
      $Zn + CuSO_4 = Cu + ZnSO_4$
   d. Binary salt and a non-metal.
      $2\ KBr + Cl_2 = 2\ KCl + Br_2$
4. DOUBLE DECOMPOSITION. (METATHESIS.)
   a. Base and an acid.
      $NaOH + HCl = NaCl + H_2O$
   x. Base and an acid-anhydride
      $2\ NaOH + SO_3 = Na_2SO_4 + H_2O$
   y. Basic oxide and an acid.
      $ZnO + H_2SO_4 = ZnSO_4 + H_2O$
   b. Base and a salt.
      $2\ NaOH + CuSO_4 = Na_2SO_4 + Cu(OH)_2$
   c. Salt and an acid..
      $NaCl + H_2\ SO_4 := NaHSO_4 + HCl$
      $Na_2CO_3 + H_2\ SO_4 := Na_2SO_4 + H_2O + CO_2$
   x. Salt and an acid-anhydride.
      $Na_2CO_3 + SiO_2 = Na_2SiO_3 + CO_2$
   d. Salt and a salt.
      $AgNO_3 + KCl = KNO_3 + AgCl$
      $KHC_4H_4O_6 + NaHCO_3 = KNaC_4H_4O_6 + H_2O + CO_2$
5. HYDROLYSIS.
      $CaCN_2 + 3\ H_2O = CaCO_3 + 2\ NH_3$
      $C_3H_5(CO_2C_{15}H_{31})_3 + 3\ NaOH = C_3H_5(OH)_3 + 3\ Na(CO_2 C_{15}H_{31})$
6. OXIDATION AND REDUCTION.
      $MnO_2 + 4HCl = MnCl_2 + 2\ H_2O + Cl_2$
      $PbS + 4\ H_2O_2 = PbSO_4 + 4H_2O$
      $Cu + O_2 + H_2SO_3 = CuSO_4 + H_2O$
      $3\ Cu + 8\ HNO_3 = 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O$

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"NORTHERN LIGHTS" STUDY MAY SOLVE RADIO MYSTERY.

By JAMES STOKLEY
Science Service Staff Writer.

The mystery of the green color of the northern lights and the problem of the Heaviside layer, believed to make long distance radio broadcasting possible, may have been solved as the result of a series of researches just completed by Dr. J. McLennan, professor of physics of the University of Toronto, and described by him to the Royal Society of London. From this work, it seems that the upper atmosphere at a height of sixty miles or more, consists largely of helium, and gas used to float dirigibles, even though at the earth's surface the air contains only a minute fraction of a per cent. of this useful gas.

A number of years ago, the English physicist, Sir William Crookes, produced what are called cathode rays by passing a high-voltage electric discharge through a tube from which the air had been exhausted. These are now known to be rapidly moving electrons, the minute electrical charges of which the atoms of matter consist. As some of these phenomena appear very much like the aurora borealis, it was suggested that cathode rays were being emitted by the sun and that when they encountered the gases in the upper atmosphere of the earth, auroras were produced. In confirmation of this theory, a Scandinavian scientist, Prof. Kristian Birkeland, placed a magnetized sphere representing the earth in a vacuum, and when he bombarded it with cathode rays, artificial auroras appeared.

But while the aurora could be partly reproduced in the laboratory, there was one effect that could not be duplicated. If a photograph is made of the northern lights, or even of the northern night sky, with a spectroscope, which analyzes the light into various colors, a prominent green line appears, along with a number of others. Prof. L. Vegard, a French scientist, worked on the problem of its origin in Leyden, Holland, at the laboratory of Prof. Kamerlingh Onnes, one of the two places in the world where extensive low temperature research is carried on. He found that many of the colors of the aurora were due to the action of the cathode rays on nitrogen; and finally, in the spring of 1924, he announced that he had obtained the green line artificially by freezing nitrogen to a solid, with a temperature of 346 degrees below zero, Fahrenheit, and subjecting it to the action of the rays.

At first, this seemed conclusive, but Prof. McLennan, director of the Physics Laboratory at Toronto, the only other laboratory in the world possessing such equipment for low temperature investigations, repeated it, with the assistance of Dr. G. M. Shrum. He found the green color, but as he used a more powerful spectroscope than had Vegard, also found that it did not agree with the line in the aurora. The line in the spectrum obtained from the solid nitrogen turned out to be triple, with one part on one side, and two on the other side, of the green line in the aurora spectrum.

In his latest work, Dr. McLennan has been able to reproduce the line artificially, in precisely the same place as it occurs in the natural aurora. As helium is so light, he supposed that the atmosphere at an altitude of 60 miles, would contain a large proportion of it, so he passed the cathode rays through a partly exhausted tube containing about 25 parts of helium to one of oxygen. The line was obtained, even though the use of oxygen or helium alone did not show it. Thus, the origin of all the observed colors in the northern lights are known, and even more important evidence is obtained as to the composition of the upper atmosphere. The Heaviside layer, supposed to consist of ionized gases which reflect radio waves back to the earth, instead of going out in space to be wasted, may consist largely of helium, and the northern lights study may lead to a better understanding of one of the greatest mysteries of radio.—*Science Service.*

RADIUM DESTROYS DANGER OF LEPROSY INFECTIONS.

The successful use of radium in the treatment of leprosy which, it is hoped, will result in the abolishment of the law of segregation that is imposed on those suffering from the dread disease, is reported by Doctors M. H. Neil and R. P. Sandidge of the Kalihi Leper Receiving Hospital at Honolulu. So far as can be discovered, this is the first use of radium in the treatment of leprosy, they state.

Following a series of experiments, the surgeons announce that in all cases treated with radium, "the leprous nodules disappeared. It is hoped that, by the use of radium many lepers may be converted from dangerous carriers, emitting millions of bacilli from their noses, to persons not dangerous to public health and thus no longer in need of segregation," they assert.

Experiments with the radium treatment of leprosy have extended over a period of six months, the study being concentrated on the use of the element with especial reference to treatment of leprous lesions of the nose.

Seven cases having nodules in the nose were treated by the insertion of a 50 milligram tube in either nostril, alternating at intervals of from two to three weeks, exposure to the treatment being from one and a half to two and a half hours.

In all cases the nodules disappeared, it is said. In three of the cases the bacteria disappeared from the area under treatment. Other similar cases, not receiving the radium treatment, showed no change in nasal condition.

"It is the intent to extend the scope of this work to determine the permanence of its effects and the effect of clearing up the nose on the patient's general condition," the investigators conclude.— *Science Service.*

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTIONS.

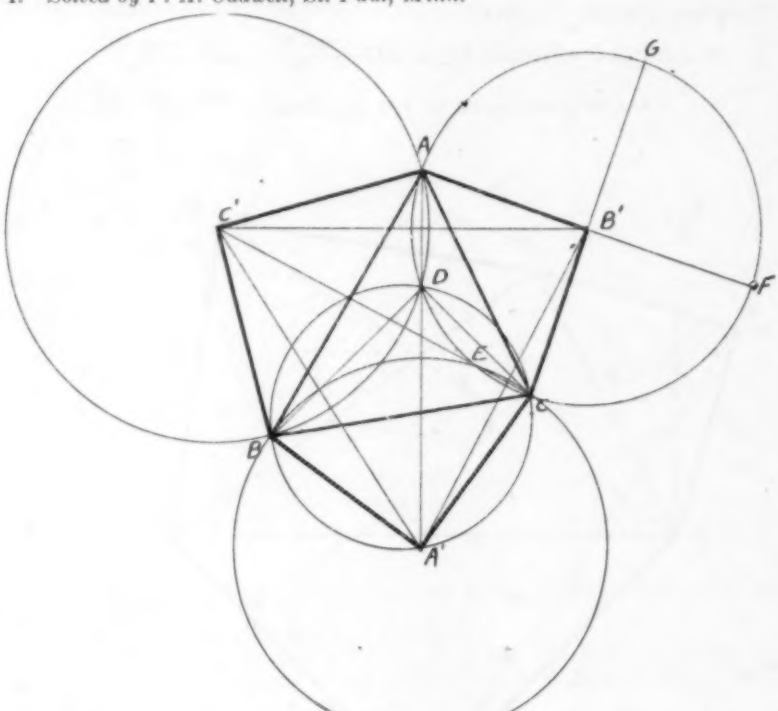
884. *H. G. Ayre, Benton, Ill.*

SOLUTIONS OF PROBLEMS.

886. *Proposed by George Sergent, Guatemala, C. A.*

If on the sides of a $\triangle ABC$ as hypotenuses, isosceles triangles $AC'B$, $BA'C$, and $AB'C$ are drawn, the diagonals of the quadrilateral formed by A', B', C' and any vertex of the given triangle are equal and perpendicular to each other. (See problem 872.)

I. *Solved by F. A. Cadwell, St. Paul, Minn.*



Draw circles with A', B' and C' as centers and $A'B$, $B'C$ and $C'A$ respectively as radii. These circles will respectively pass through B and C, C and A, A and B.

Let D be the other intersection of circles B' and C' and E the other intersection of circles A' and B'.

On BC as diameter draw a circle. This circle will pass through A′ because angle BA′C is a right angle; and it will pass through D because the minor arcs subtended by AB and AC equal 90° each and therefore angle ADB plus angle ADC = 270°, leaving angle BDC = 90°.

Draw AD, A′D, BD and CD. Angle ADB = 135° since it is measured by ½ an arc of 270°, and angle A′DB = 45° since it is measured by ½ arc A′B of 90°. Therefore ∠A′DB + ∠ADB = 180°. Therefore points A′, D and A are collinear and A′DA is a straight line.

Draw C′B′, A′B′, A′C′, AC′, AB′ and CC′. CC′ will pass thru E, as it may be shown that C′, E and C are collinear in the same way that A′, D and A were shown to be collinear. AD is the common chord of circles B′ and C′. Therefore B′C′ is perpendicular to AD and also bisects both arcs AD. (The line of centers of two circles which intersect is perpendicular to their common chord.)

Therefore A′A is perpendicular to B′C′.

Prolong AB′ and CB′ to meet circle B′ again at F and G respectively.

Then $\angle A'AB'$ is measured by ½ arc $DECF = \frac{180° - \text{arc } AD}{2}$.

$$= 90° - \frac{\text{arc } AD}{2}.$$

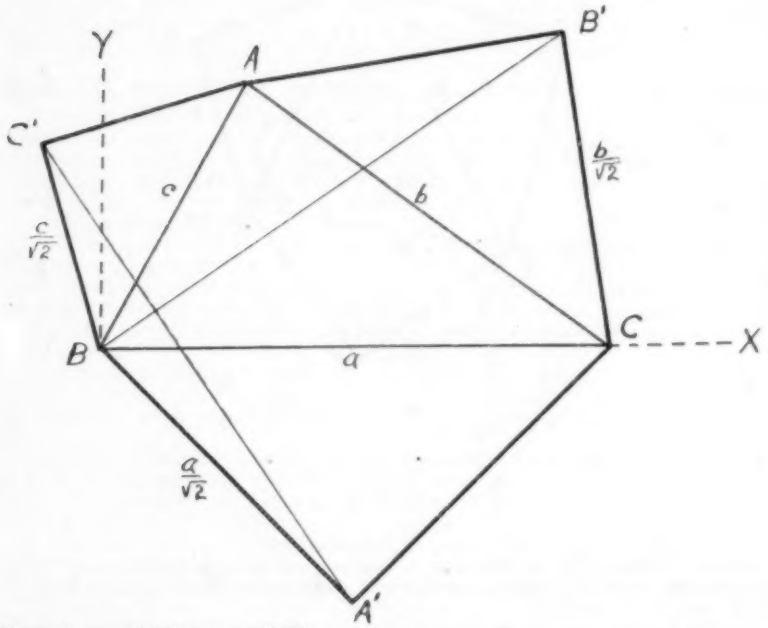
$\angle CB'C'$ is measured by arc $AC = \frac{\text{arc } AD}{2} = 90° - \frac{\text{arc } AD}{2}$.

Therefore $\angle A'AB' = \angle CB'C'$.

$\angle A'B'A$ is measured by arc $AC - \frac{\text{arc } EC}{2} = 90° - \frac{\text{arc } EC}{2}$.

$\angle C'CB'$ is measured by 1/2 arc $EDAG = \frac{180° - \text{arc } EC}{2}$.

$$= 90° - \frac{\text{arc } EC}{2}.$$



Therefore $\angle A'B'A = \angle C'CB'$.

Then in triangles A′AB′ and C′CB′:

$\angle A'B'A = \angle C'CB'$ and $\angle A'AB' = \angle CB'C'$. (Proved.)
Side $AB' =$ side CB' (radii of same circle).
Therefore triangles $A'AB'$ and $C'CB'$ are congruent.
Therefore $A'A = C'B'$.

II. *Solved by J. F. Howard, San Antonio, Texas.*

Choose as rectangular axes BC and BY. Let the coordinates of A be (k, l); of C be (m, o). Then it may easily be shown that C′ is $\left[\frac{k-l}{2}, \frac{k+l}{2}\right]$, A′ is $\left[\frac{m}{2}, -\frac{m}{2}\right]$, and B′ is $\left[\frac{l+m+k}{2}, \frac{l+m-k}{2}\right]$.

Hence

$$(BB')^2 = \left(\frac{l+m+k}{2}\right)^2 + \left(\frac{l+m-k}{2}\right)^2.$$

$$\text{and } (A'C')^2 = \left(\frac{-k+l+m}{2}\right)^2 + \left(\frac{k+l+m}{2}\right)^2.$$

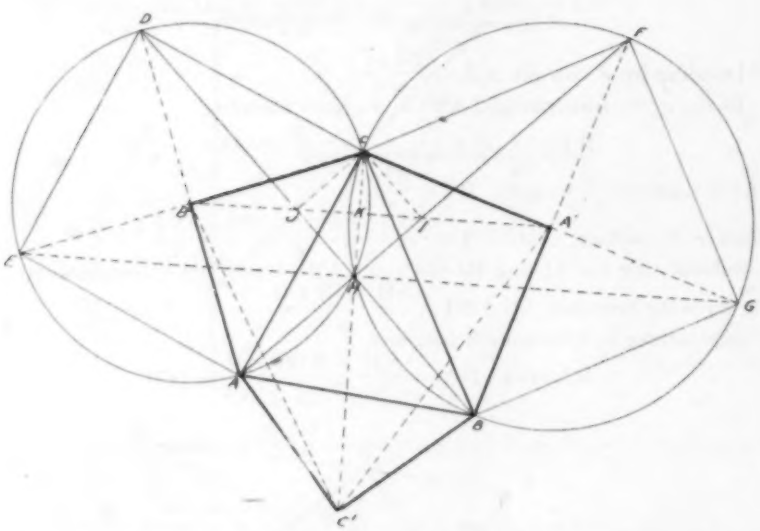
Therefore, $BB' = A'C'$.

(By using the cosine theorem, it can be easily proved that $BB' = A'C'$.)

Slope of BB′ is $\frac{l+m-k}{l+m+k}$, and the slope of A′C′ is $\frac{k+l+m}{k-l-m}$.

Since the product of the slopes of BB′ and A′C′ equals unity the lines BB′ and A′C′ are perpendicular to each other.

III. *Solution by the Proposer.*



Proof: Let us consider the quadrilateral A′C′B′C, whose diagonals are A′B′ and C′C.

Construct the squares ACDE and BCFG.

(1) As shown in problem 871, the lines AF, BD, EG are concurrent in H, point of intersection of the circles circumscribed to the squares ACDE and BCFG.

$\angle DHC = \angle FHC = \frac{1}{2}$ right angle.

Consequently HC is bisector of the right $\angle DHF$.

The $\angle$'s AHB and AC′B being right angles, AC′BH is a cyclic quadrilateral, and since $AC' = BC'$, the $\angle$'s AHC′ and BHC′ are each equal $\frac{1}{2}$ right angle, and CHC′ is a straight line, and is also perpendicular to EHG, bisector of the right $\angle$'s AHD and BHF.

A'B' joining the midpoints of the sides CE and CG of the △ECG is parallel to EG, and consequently perpendicular to C'C, which was to be proved.

(2) A'B' equals ½ EG and bisects CH.

Let K, I and J be the intersections of A'B' with CH, AF and BD respectively.

CK = KH, CI = HI, and CJ = JH.

The △'s CIH and CJH are isosceles right triangles. Therefore the quadrilateral CIHJ is a square.

Let its side be l. Then $CH = IJ = l\sqrt{2}$.

Formula for C'C. In the cyclic quadrilateral AHBC' we have by Ptolemy's theorem:

$$C'H \times c = AH \times \frac{c}{\sqrt{2}} + BH \times \frac{c}{\sqrt{2}}.$$

Dividing by c, (which is the side AB), we have

$C'H = \frac{AH + BH}{\sqrt{2}}$, whence $CC' = C'H + HC$ and

$$CC' = \frac{AH + BH}{\sqrt{2}} + l\sqrt{2}. \qquad (1)$$

Formula for A'B'.

$A'B' = A'J + B'I - IJ = A'J + B'I - l\sqrt{2}$.

In the cyclic quadrilateral A'BJC

$$A'J \times a = BJ \times \frac{a}{\sqrt{2}} + l \times \frac{a}{\sqrt{2}} = (BJ + l)\frac{a}{\sqrt{2}}.$$

Dividing by a, we get $A'J = \frac{BJ + l}{\sqrt{2}}$.

In the cyclic quadrilateral AB'CI, we have likewise:

$$B'I \times 6 = AI \times \frac{6}{\sqrt{2}} + l \times \frac{6}{\sqrt{2}} = (AI + l)\frac{6}{\sqrt{2}},$$

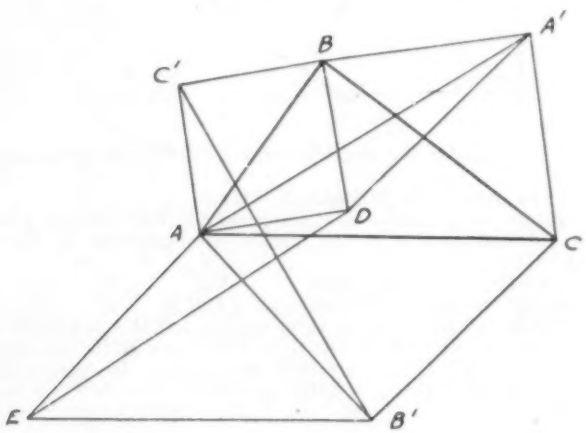
and dividing by b, we get: $B'I = \frac{AI + l}{\sqrt{2}}$,

whence, by adding, $A'J + B'I = \frac{BJ + l + AI + l}{\sqrt{2}} = \frac{BJ + AI + 2l}{\sqrt{2}}$.

Substituting for AI and BJ the sums $AH + l$ and $BH + l$ respectively, the equality becomes: $A'J + B'I = \frac{AH + BH + 4l}{\sqrt{2}}$

Subtracting $l\sqrt{2}$ from each member

$$A'J + B'I - l\sqrt{2} = \frac{AH + BH}{\sqrt{2}} + \frac{4l}{\sqrt{2}} - l\sqrt{2}.$$



Since $\frac{4l}{\sqrt{2}} = \frac{4l\sqrt{2}}{2} = 2l\sqrt{2}$, we have by substitution and reduction

$$A'J + B'I - l\sqrt{2} = A'B' = \frac{AH + BH}{\sqrt{2}} + l\sqrt{2}. \qquad (2)$$

Comparing (1) and (2), we get $A'B' = C'C$.

IV. *Solved by Michael Goldberg, Philadelphia, Pa.*

Rotate AC^1B about the line AB so that C^1 will occupy the position D. Rotate AB^1 through 90° clockwise (See figure) about A so that B^1 will occupy the position E. Then since $ABD = CBA^1 = 45°$, $\angle DBA^1 = \angle ABC$, $AB = \sqrt{2}\ DB$, $BC = \sqrt{2}\ BA^1$.

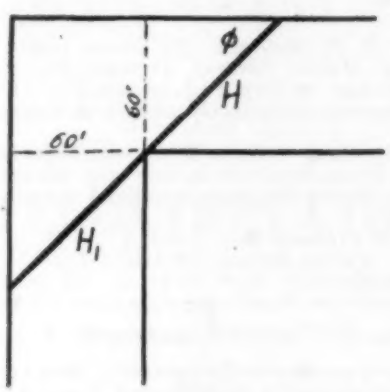
$\triangle DBA^1$ is similar to $\triangle ABC$, each pair of corresponding sides making an angle of 45°, the ratio of each pair of corresponding sides being $\sqrt{2}:1$

AE makes an angle of 45° with AC and equals $\frac{AC}{\sqrt{2}}$. Therefore AE is equal and parallel to DA^1. Thus AA^1 is parallel and equal to ED. If $\triangle AED$ is rotated counter-clockwise through 90° it will take the position AB^1C^1. Therefore $B^1C^1 = AA^1$ and the angle between them is 90°.

887. *Proposed by C. E. Githens, Wheeling, W. Va.*

Two streets, each 60 feet wide cross at right angles. Neglecting the width and thickness of the obelisk, and the width of the sidewalks what is the longest obelisk that could be moved around the corner?

I. *Solved by W. W. Horner, Donora, Pa.*



Denote the length of the required obelisk by x or $(H_1 + H)$. (See figure.)

$H = 60\ sec\ \phi$.

$H_1 = 60\ csc\ \phi$.

$H + H_1 = x = 60\ sec\ \phi + 60\ csc\ \phi$.

Our first problem is to find the value of ϕ such that x shall have the maximum value. By the differential calculus we know that

$$\frac{dx}{d\phi} = 60\ sec\ \phi\ tan\ \phi - 60\ csc\ \phi\ cot\ \phi = 0.$$

Transposing and dividing by 60 $csc\ \phi\ cot\ \phi$ we have $tan^3\phi = 1$, or $tan\phi = 1$, or $\phi = arc\ tan\ 1 = 45°$.

$\therefore x = 60\ sec\ 45° + 60 csc\ 45° = 120\sqrt{2}$ ft.

(See figure.) The equation of a straight line through points (a, o) and (o, b) is

$$\frac{x}{a} + \frac{y}{b} = 1. \qquad (1) \qquad \text{(Figure.)}$$

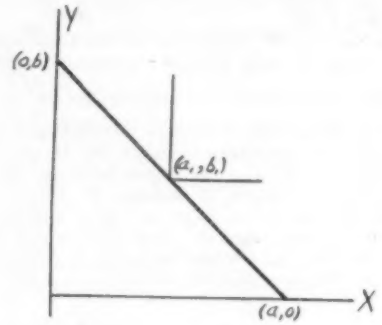
since the line passes through a_1, b_1

$$\frac{a_1}{a}+\frac{b_1}{b}=1. \qquad (2)$$

The length of the line segment is $d=(a^2+b^2)^{\frac{1}{2}}$. Differentiating, and setting equal to zero, we have

$$(a-a_1)^3=a_1b_1^2.$$

But by hypothesis $a_1=b_1$, hence $a=2a_1=120$, and $b=2b_1=120$. Therefore $d=120\sqrt{2}$ feet.



Also solved by *R. T. McGregor, Elk Grove, Calif.*; *T. E. N. Eaton, Redlands, Calif.*; *J. Murray Barbour, Ardmore, Pa.*; *J. F. Howard, San Antonio, Texas*; *Michael Goldberg, Philadelphia, Pa.* (Interesting applications of this problem are given in Granville's Calculus, Revised Edition, Editor.)

888. *Proposed by Walter C. Eells, Whitman College, Walla Walla, Wash.*

For what value or values of s is it true that the cube of any integer, when divided by s, leaves the same remainder as does the integer itself when divided by s?

[Generalization of Problem 873. Editor.]

I. *Solved by J. Murray Barbour, Ardmore, Pa.*

Let a be any integer.

Since, it is assumed that a^3 and a leave the same remainder when divided by s, it follows that $\frac{a^3-a}{s}$ leaves no remainder. But $(a^3-a)=a\ (a+1)\ (a-1)$; that is, this numerator is the product of three consecutive integers. It is known that this product is divisible by 2, 3, and 6, hence $s=2$, 3, or 6.

II. *Solved by J. S. Georges, University High School, Chicago.*

Let x be any integer, a the remainder when divided by s. Then $x\equiv a \bmod s$ and $x^3\equiv a^3 \bmod s$. Since $x^3\equiv a \bmod s$, a^3 and a must satisfy the condition $a^3\equiv a \bmod s$. When $s=2$, the possible remainders are 1 and 0. Then $1^3\equiv 1 \bmod 2$, and $x^3\equiv 1 \bmod 2$, hence $x\equiv 1 \bmod 2$. When $x\equiv 0 \bmod 2$, then $x^3\equiv 0 \bmod 2$, hence $s=2$ satisfies the condition. When $s=3$, the possible remainders are 2, 1, and 0. Then $2^3\equiv 2 \bmod 3$ and $1^3\equiv 1 \bmod 3$. Hence $s=3$ satisfies the condition. Since $s=2$ and $s=3$ satisfy the condition, then $s=(2\times 3)$ will also satisfy the condition.

III. *Solved the Proposer.*

Any integer N can be written in the form

$$N=sn+k \quad (s=1, 2, 3, \ldots; n=1, 2, 3, \ldots; k=1, 2, 3, \ldots s-1).$$

Then $$N^3=s^3n^3+3\,s^2n^2k+3\,snk^2+k^3=sM+k^3$$

From this form it is evident that the remainder when N^3 is divided by any s can be easily found from the remainder for the corresponding k^3, which can then be compared with the remainder for corresponding k's in the expression for N. If we let r, and R, represent the remainders for corresponding values of k and k^3, we have for successive values of s:

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$s=3$. $k=0, 1, 2$
$k^3=0, 1, 8$
$r=0, 1, 2$
$R=0, 1, 2$ and therefore the property is true for $s=3$.

$s=4$. $r=0, 1, 2, 3$.
$R=0, 1, 0, 3$. The property is not true.

$s=5$. $r=0, 1, 2, 3, 4$
$R=0, 1, 3, 2, 4$. The property is not true.

$s=6$. $r=0, 1, 2, 3, 4, 5$
$R=0, 1, 2, 3, 4, 5$. The property is true for $s=6$.

$s=7$. $r=0, 1, 2, 3, 4, 5, 6$
$R=0, 1, 1, 6, 1, 6, 6$. The property is not true.

$s=8$. $r=0, 1, 2, 3, 4, 5, 6, 7$
$R=0, 1, 0, 3, 0, 5, 0, 7$. The property is not true.

$s=9$. $r=0, 1, 2, 3, 4, 5, 6, 7, 8$
$k^3=0, 1, 8, 27, \cdot\ \cdot\ \cdot\ \cdot\ \cdot$
$R=0, 1, 8, 0, 1, 8, 0, 1, 8$. It is evident that the property is not true, not only for $s=9$, but for $s>9$ since the third R will always be 8 and therefore different from the third r which is 2.

Therefore the cube of any integer, when divided by s, leaves the same remainder as does the integer itself when divided by s, if and only if s is 2, 3, or 6.

Also solved by J. F. Howard, San Antonio, Texas; W. W. Horner, Donora, Pa.; and *T. E. N. Eaton, Redlands, Calif.; and Michael Goldberg, Philadelphia, Pa.*

889. *Proposed by C. N. Mills, Aberdeen, S. Dakota.*

Proved that the area of the largest square that can be inscribed in a semi-circle of radius r is $4r^2/5$.

Solved by F. A. Cadwell, St. Paul, Minn.

Remark. If by "inscribed in a semicircle" it is meant that each vertex of the square is on either the diameter or the circumference of the semi-circle, there can be only one inscribed square. Hence the word "largest" as used in the problem is superfluous.

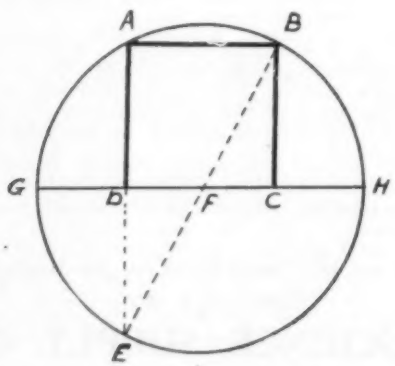
Let ABCD be the square inscribed in the semicircle GABH.

Draw the semi-circle on the opposite side of GH, thus completing the circle.

Prolong AD to meet the circle again at E.

Draw EB. Since $\angle BAE$ is a rt. $\angle$, EB will pass through F, the center of the circle.

Then $AB^2+AE^2=EB^2=4r^2$



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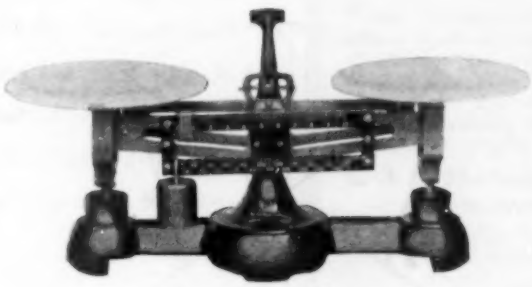

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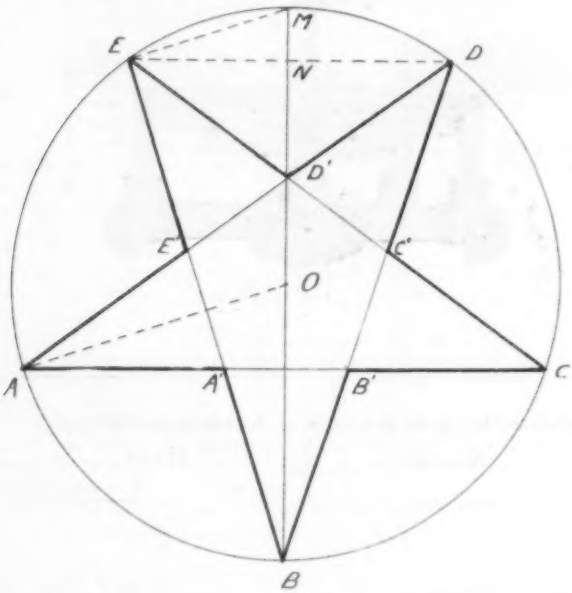
Because FD is perpendicular to AE it bisects AE.
$\therefore AE = 2AD = 2AB$ and $AE^2 = 4AB^2$
$\therefore AB^2 + AE^2 = AB^2 + 4AB^2 = 5AB^2 = 4r^2$
$\therefore AB^2 = 4r^2/5$.

Also solved by *George Sergent, Guatemala, C. A.; J. S. Georges, University High School, Chicago; T. E. N. Eaton, Redlands, Calif.; J. F. Howard, San Antonio, Texas; W. W. Horner, Donora, Pa.; R. T. McGregor, Elk Grove, Calif.; J. Murray Barbour, Ardmore, Pa.; Tillie Dantowitz, Philadelphia, Pa., and Michael Goldberg, Philadelphia, Pa.*

890. *For High School Pupils. Proposed by J. S. Georges, University High School, Chicago*

Find the area of the five-pointed star whose diagonal is a.

Solved by the Proposer.



Let $AE' = y$; $E'D' = Z$, and $EM = z$. Then $2y + x = a$.
$aZ = 2r \cdot EN = (2rax)/2y$.
Hence $z = (xr)/y$. Since $z = r(\frac{\sqrt{5}-1}{2})$, we have $x = y(\frac{\sqrt{5}-1}{2})$. Therefore $y = \frac{a}{2}(3-\sqrt{5})$, and $x = a(\sqrt{5}-2)$. The area of the sta is equal to $\triangle BE'D + 3\triangle AA'E'$, which is represented by

$$\sqrt{\left(\frac{a+x+y}{2}\right)\left(\frac{x+y-a}{2}\right)\left(\frac{a}{2}\right)\left(\frac{a}{2}\right)} + 3\sqrt{\left(\frac{y+x}{2}\right)\left(\frac{y-x}{2}\right)\left(\frac{x}{2}\right)\left(\frac{x}{2}\right)}.$$

Hence the area $= \frac{a}{4}\sqrt{4(x+y)^2 - a^2} + \frac{3x}{4}\sqrt{4y^2 - x^2}$.

Substituting the above values for x and y the area of the star is

$$\frac{a^2}{4}(3\sqrt{5}-5)\sqrt{5-2\sqrt{5}}.$$

Also solved by *Tillie Dantowitz, Philadelphia, Pa.*, the result being left in a complex fomr.

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PROBLEMS FOR SOLUTION.

901. *Selected.*

David Eugene Smith, in his new "History of Mathematics" (Vol. I, p. 454), says: "Nicholas Saunderson deserves mention, not so much because of his great achievements in advancing the science as on account of the inspiration that his history offers to those who labor under difficulties such as to discourage most men and lead them early to abandon hope. When only one year of age he became blind through an attack of smallpox. He was a pupil of Whiston's, who was then Lucasian professor of mathematics at Cambridge, and succeeded him in 1711. He was created doctor of laws in 1728 by the command of George II, and became a fellow of the Royal Society in 1736. He was a very successful teacher, and is especially known for his *Algebra*, published posthumously in 1740–1741, and translated into French. He could carry long and complicated mathematical problems mentally, which partly accounts for his success in spite of his misfortune." In Vol. II of his *Algebra* is found the following problem:

"Whoever makes a tour around the earth must necessarily take a larger compass with his head than with his feet. The question is, how much larger?

902. *Proposed by Michael Goldberg, Philadelphia, Pa.*

Show that the fourth power of the infinite continued fraction

$$1+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+}}}$$

in the infinite continued fraction

$$7-\cfrac{1}{7-\cfrac{1}{7-}}$$

908. *Proposed by Daniel Kreth, Wellman, Iowa.*

Given the difference of the sides, the difference of the angles at the base, and the radius of the inscribed circle; to construct the triangle and calculate its sides.

904. *Proposed by J. J. Sheekey, Normal Institute, Ammendale, Md.*

Under what condition will x^3+ax^2+bx+c be divisible by x^2+px+q?

905. *For High School Pupils. Proposed by Tillie Dantowitz, Philadelphia, Pa.*

The side AB of a parallelogram ABCD is produced to point P. The line DP interesects AC at E and BC at F. A circle is drawn through B, F and P. From E a tangent EK to this circle is drawn. Prove that the perpendicular bisector of DK passes through E.

Note: For problem 899 proposed in the November issue the equation $XYZ=1$ was omitted—Ed.

STUDENTS ARE YACHT BUILDERS AND STONE WORKERS.

Dominant local industries inevitably affect the studies in the schools of any community. San Diego, Calif., for example, is on a bay which is large enough to give safe anchorage to 300 battleships, and it is rare that the harbor is without a considerable number of them. Many of the people of the city look to the ocean for their livelihood or for their principal diversion. The courses of the school shops reflect that condition. Nothing else in those shops arouses so much interest as the building of boats and of models of racing craft. Yachting enthusiasts and expert boat builders encourage this study and cordially cooperate with the shop teachers.

Similarly, in Bedford, Ind., the center of a great quarrying district, stone drafting and stone working are strongly emphasized. The senior high school has a complete equipment for planing stone and for shaping and dressing it, and the vocational courses offered are of the most practical character. Numbers of the boys elect those courses, for they are not only of great interest in themselves but they lead to remunerative work after graduation.—School Life.

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Key.

To all who attempted unsuccessfully to read *Science Questions* for October, 1925, the following directions will be of assistance:

The *Newspaper Clipping* mentioned at the bottom of page 760 will be found on page 764.

From the bottom of page 764 turn to page 762.

From the bottom of page 762 turn to page 766, thence to page 768.

Now, having found your way, *read No. 472 and send in a solution.*

QUESTIONS FOR SOLUTION.

475. *The Bendix Drive and Physical Principles.*

(*a*) List in order the physical and mechanical principles involved in starting a car equipped with a Bendix drive.

(*b*) In particular explain why the gear engages and why it disengages.

EXAMINATION PAPERS.

476. *Proposed by W. J. Reimer, East Stroudsburg (Pa.) High School, January, 1925.*

While reading the "School Science and Mathematics" I noted several copies of science examination papers in which I was very much interested.

Last year I became very much interested in a one-word answer examination. I made out several examinations of this type in chemistry and physics and gave them to my classes with good results.

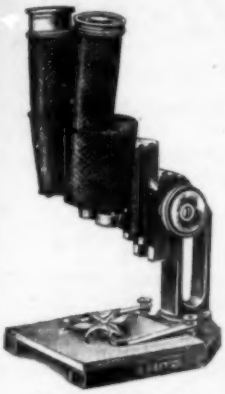
I am enclosing a copy of my mid-year and final examinations in physics given to a group of Juniors of the East Stroudsburg High School last year. The questions are mostly of the one-word answer type and may be of interest to some.

PHYSICS—MID-YEAR.

W. J. Reimer.

East Stroudsburg (Pa.) High School, January, 1925.

1. Define Physics.
2. What is a six letter word meaning that which occupies space?
3. What is a six letter word meaning the universal agency by means of which work is done?
4. All forms of matter having size and shape and offering resistance to a change of shape or size are called————.
5. What is a 5 letter word meaning that which produces motion or change of motion?
6. All forms of matter having definite size but not shape are called ————.
7. All forms of matter having neither definite size nor shape are called ————.
8. Three dimensional geometry is based on what property of matter?
9. A liquid rises when a solid object is placed in it. What property of matter is involved?



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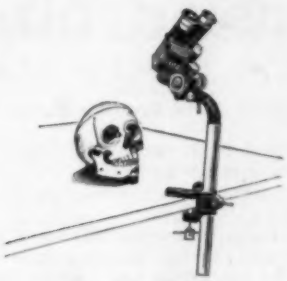

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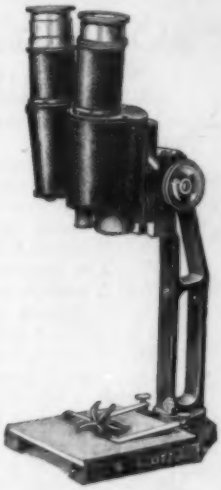

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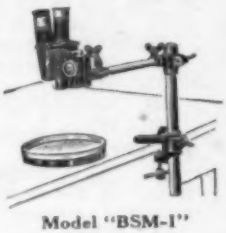

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10. Define inertia.
11. What is an 8 letter word meaning force of attraction between molecules?
12. Copper may be used as an example of what 2 properties of matter?
13. What is an 11 word meaning aptness to break under a blow?
14. What system of measurement is used in science?
15. What is meant by C. G. S.?
16. What is a 9 letter word meaning mixing of gases, liquids or solids?
17. The passing of a gas through a clay cup is called ———.
18. A needle carefully placed on the surface of water, floats. Why?
19. A liquid rises 10cms. in a tube .5.m.m. in diameter. How high will it rise in a tube .25.m.m. in diameter?
20. Why do farmers plow?
21. Give 3 reasons for a liquid rising in a tube of small diameter when placed in a jar of the liquid.
22. What is a 6 letter word meaning either change in size or shape of an object?
23. What is a 6 letter word meaning that which produces a change in the size or shape of an object?
24. What is a 10 letter word meaning the recovery from the change in the size or shape of an object?
25. A force of 5 lbs. distorts an object 1 inch. What weight is necessary to distort it 2 inches?
26. Whose law is involved in 25?
27. What is Pascals principle?
28. A force of 10 lbs. is exerted on the small piston of a hydraulic press which lifts a weight of 500 lbs. on a piston 20 inches in diameter. What is the diameter of the small piston?
29. A city reservoir is 500 ft. above the lowest street. If no pumps are used, what is the distance from the highest story of a building in which the water is to be used to the lowest street?
30. What 2 forces act on the hydraulic ram?
31. What is an 8 letter word meaning the lifting force of a liquid on a body immersed in it?
32. What is Archimedes' principle?
33. What formula is used to find density?
34. What formula is used to find specific gravity?
35. State 3 methods of finding specific gravity.
36. Name 2 men who experimented with atmospheric pressure.
37. What is a 9 letter word meaning a measure of atmospheric pressure?
38. (a) A certain gas has a volume of 500 c.c. under a pressure of 380 m.m. If the temperature remains constant what is the volume under standard pressure?
(b) Whose law is involved?
39. How high will a balloon rise?
40. Given a pipe 1 mile long how would you run the water of a reservoir 500 ft. above sea level over a hill 530 ft. above sea level to a town three-fourths of a mile from the hill?
41. What is the greatest distance from the lower valve of a suction pump to the water in a well?
42. Name 4 types of motion.
43. What is a 12 letter word meaning change in speed per unit of time?
44. How far will a sled travel down a hill in 3 secs. if the change in speed per unit of time is 40 cms. per sec. per sec.? Give formula only.
45. What is a 4 letter word meaning force which imparts to a gram mass an acceleration of one cm. per sec. per sec.?
46. What 2 things must the graph of any force represent?
47. What is a 9 letter word meaning a single force which will produce the same effect that a number of forces will when acting together?
48. Two horses are pulling a load weighing 1,000 lbs. If one horse pulls 600 lbs. and the other 400 lbs., at what point is the 5 ft. doubletree fastened?

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49. Two forces of 20 and 30 grams respectively act on a point at an angle of 45 degrees. How would you find the resultant force?
50. What is an 8 letter word meaning force of a moving body?
51. What is a 7 letter word meaning the attraction of the earth for all bodies?
52. What is a 7 letter word meaning force through time?
53. State 2 laws of motion.
54. What is a 6 letter word meaning measure of attraction of the earth?
55. Name 3 kinds of equilibrium.
56. The dairy separator is an example of what force?
57. What is a 6 letter word meaning the time it takes a pendulum to make a to and fro movement?
58. What is a 4 letter word meaning the action of force through distance?
59. What is a 3 letter word meaning the work done by a dyne acting through a distance of 1 cm.?
60. What is a 5 letter word meaning the rate of doing work?
61. Name 2 kinds of energy.
62. Give the general law of machines.
63. Why is perpetual motion impossible?
64. Give the formula used to find the efficiency of a machine.
65. Name 6 machines.
66. Give 2 sentences describing the nature of heat.
67. What is an 11 letter word meaning the degrees of heat?
68. What 2 words when used together mean quantity of heat?
69. 5/9 degree C.———how many degrees F.?
70. Define coefficient.
71. Derive the formula used to find the coefficient of cubical expansion.
72. Every gas upon cooling 1 degree C. increases or decreases—— of its volume.
73. What is the absolute zero point?
74. How much heat is required to convert 1 gram of ice into water at 10 degrees C?
75. Is heat given out or absorbed when a solid goes into solution?
76. Define Dew point.
77. Give the titles of 6 experiments.
78. How is the mechanical advantage of a machine found?

SOLUTIONS AND ANSWERS.

459. *Proposed by A. G. Haynes, Bishop Colton School, Bangalore, South India.*

Solved by A. G. Haynes,
James W. Miller, Calumet H. S., Chicago, Ill.,
Eric R. Brater, Cleveland, Ohio,
Philip L. Wright, Cleveland, Ohio.

Solutions will be mailed to any who are interested in seeing them.

473. New Type Chemistry Examination—Western Reserve University, June, 1925.

(a) Do you favor *New Type* questions as given in Part A? (Will each reader send in a vote *at once?* If you don't answer, the Editor will think you don't read.)

(b) How can a student *study* for such an examination? Is it desirable that he should?

(c) Should examinations be abolished? Why?

(For examination questions see SCHOOL SCIENCE AND MATHEMATICS, Oct. 1925. Pages 764, 762, 766, and 768.)

Answer by Miss Annie Cloyd, Fairmount College, Wichita, Kansas.

I do *not* favor (a) the New Type questions as given in Part A. Their range of information is too limited.

(b) The student could not study for such an examination. If his work is *well done, st dying* for an examination is neither *necessary or* desirable.

(c) Perhaps the emphasis now placed on examinations should be

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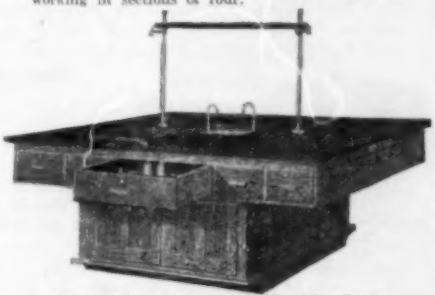

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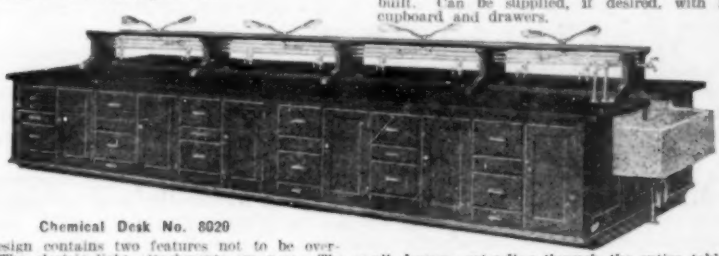

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lessened, yet they have their good points in spurring up some lazy students to take more interest in their work something in the order of a hurdle to be successfully accomplished.

474. College Board Chemistry, 1925:

(a) Which is a better examination, the Western Reserve New Type examination or the College Board examination? (Please vote! A vote is wanted from every reader.)

(b) Are there any New Type questions on the Board list? Do you think there should be?

(c) Is this Board examination too complicated in method of giving choices of questions?

Answer by Miss Annie Cloyd, Fairmount College, Wichita, Kansas.

It seems very clear to me.

Judging from other standardized tests in Chem., it still seems to me that the Board questions are very difficult. I have expressed that opinion before. Would there be any way of finding out what percentage of those who took that examination failed it?

Respectfully yours,

ANNIE CLOYD,
Fairmount College,
Wichita, Kan.
(Instructor in Freshmen Chem.).

474. (a) I think the College Board examination is the better one.

(b) Question 9 of Board Exam. is on the order of the New Type of questions. Some of that kind of question might be included to give variety.

(c) Seems to me any one ought to be able to understand the method of choice of questions used in the Board Examinations. It seems very clear to me.

KITCHEN SOAP KILLS GERMS.

Soap has a value as an aid to health even greater and more direct than has hitherto been suspected. The ordinary routine of diswashing and laundering or cleaning the face and hands is fatal to germs of such dangerous diseases as pneumonia, diphtheria, blood poisoning and other serious infections. Dr. John E. Walker of the Service Laboratory of the Army and Navy General Hospital at Hot Springs, Arkansas has just concluded extensive experiments which showed that common soaps were effective germicides in at least three types of infections, while soap made with coconut oil was markedly destructive to the organisms of typhoid fever.

The soap in greatest use around hospitals is the "official soft soap.', The substitution of coconut oil for the linseed oil used in making this soap Dr. Walker said, would render it germicidal against the typhoid bacillus as well as against the other three organisms. Although this change would make the soap more irritating to the skin, the change would be desirable and it would be useful in case of typhoid epidemics.

All the soaps tested were more antiseptic at higher temperature. The organism causing boils, known technically as Staphylococcus aureus, completely resisted all soaps, even at a higher temperature, except a sodium resin soap.

Dr. Walker found that when the hands were washed with ordinary care the lather formed contained about eight per cent of soap. This amount he said was more than enough to kill the pneumonia, diphtheria, and streptococcus bacilli. The most careful washing of hands, however, did not kill the staphylococcus or boil-forming organisms, which showed that soaps alone could not be relied upon for complete surgical sterility.

In spite of claims put forth by manufacturers of special soaps, they were found to be no more effective than the average household kind. Foreign substances mixed with the soap often interfered markedly with the germicidal action.—*Science Service.*

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WISCONSIN ASTRONOMER DISCOVERS STELLAR SPEEDERS.

By James Stokley

Science Service, Staff Writer

Runaway stars and new variable stars that periodically become bright and then faint are being discovered by Prof. Frank E. Ross, of the Yerkes Observatory, as a result of the study of photographic plates in the observatory's files. Various fields of stars, largely in the Milky Way, were photographed some twenty years ago by the late Prof. E. E. Barnard who used the Bruce photographic telescope. This instrument is a camera with several lenses, the largest ten inches in diameter, and it is mounted so as to follow the stars in their apparent daily motion across the sky. Thus these photographs show the sky as it appeared about two decades ago. To discover what has happened in the interval, Prof. Ross is comparing them with similar photographs which he is making of the same regions through the Bruce telescope.

To compare two pictures, each showing thousands of tiny dots representing stars, all but half a dozen of which are precisely the same, and to locate the ones that have moved or otherwise changed in the interval, would seem like a hopelessly complicated task, but the use of an ingenious instrument known as the blink microscope makes it relatively easy. This consists of what might be called a double periscope. One photographic plate is placed at each end. By oscillating a small lever, the observer can see first one and then the other in as rapid succession as he desires. The stars that are the same on each plate undergo no change in appearance, but if one has moved, between the two exposures, it seems to dance to and fro as the lever is moved. If a star has varied in light, the image dot seems to grow larger and smaller, while if a new star has burst out, its image will appear and disappear.

So far, Prof. Ross has examined twenty-five pairs of plates in this way and has found more than 150 rapidly moving, or "proper motion" stars, and 40 variables, that were not known before. Some of the proper motion stars are moving faster than two seconds of arc a year, which in about 900 years would take them over a distance equal to the moon's apparent diameter in the sky. This may not seem very rapid, but the most rapid star in the sky known to astronomers, which was also discovered by Prof. Barnard, is only moving at about five times this speed. And of the countless legions of stars only about 200 have been known up to the present that move faster than one second of arc a year.

But these plates only measure motion across the sky, and if a star happens to be moving directly to or from the earth, its motion will not be apparent. Such motion, called "radial velocity," may be detected by analyzing the star's light in a spectroscope, for the light waves are crowded together from an approaching star, and spread out if it is receding. A similar effect makes a fire engine bell, for example, seem shriller when coming towards one than when going away.

For three nights a week, when weather permits, the great 40 inch refracting telescope at Yerkes, the largest of its kind in the world, is used to make these spectrum photographs. This work was begun by Prof. Edwin B. Frost, director of the observatory, and is now being carried on by Prof. S. B. Barrett and Dr. Otto Struve. Dr. Struve is a young Russian astronomer, and belongs to the third generation of a family of astronomers that includes some of the best known names in the history of the science.—*Science Service.*

A recent notice in the daily papers describes a plan made by the Pan-Pacific Biology Commission to make the Island of Ohau of the Hawaiian group a Pan-Pacific Botanical Garden. It is planned to grow on the Island every kind of tropical fruit and other plants of economic importance, while on the mountain slopes will be grown economic plants from other parts of the world. Many plants from other parts of the tropics are already being grown on the research grounds of the Pan-Pacific institute of Ohau and seed and cuttings are being constantly received. —*Torreys.*

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Professor of the Technique of Instruction in Science, University of Nebraska

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Head of the Department of Chemistry, Shortridge High School, Indianapolis

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ARTICLES IN CURRENT PERIODICALS

American Botanist, for October, *Joliet, Illinois, $1.50 a year, 40 cents a copy.* "Cousins of the Cactus," Willard N. Clute; "The Meaning of Plant Names—XXIV Gentianaceae," Willard N. Clute; "The Opening of Flowers," Donald C. Peattie.

American Journal of Botany, for November, *Brooklyn Botanic Garden, $6.00 a year, 75 cents a copy.* "The Biology and Pathology of Some of the Hardwood Heart-Rotting Fungi." Part II. Dow V. Baxter; "The Elongation of Root Hairs as Affected by Light and Temperature," R. E. Jeffs.

American Mathematical Monthly, for October, *Lancaster, Pa., $4.00 a year, 45 cents a copy.* "In the Surnamed Chosen Chest: II. Orientalia," D. E. Smith; "On a Central Difference Summation Formula," W. A. Jenkins; "The Path of Light in a Gravitational Field," C. C. Wylie; "Note on Neuberg's Cubic Curve," Frank Morley; "Application of the Theorem of Residuation to the 21-point Cubic," O. M. Thalberg; "American Contributions to Mathematical Symbolism," Florian Cajori.

QUESTIONS AND DISCUSSIONS: Discussions—"Derivation of Annuity Formulas Without Series," F. R. Morris; "Errata in Steinhauser's 20-place Logarithm Table," E. B. Escott.

Condor, for September-October, *Berkeley, California, $3.50 a year, 50 cents a copy.* "The Birds of Fanning Island," Central Pacific Ocean (with eight photos), Harold Kirby, Jr.; "A Report on the Birds of Northwestern Alaska and Regions Adjacent to Bering Strait," Part V (with three photos), Alfred M. Bailey.

Chemical Education, for October, *Easton, Pa., $2.00 a year.* "The Life and Chemical Services of Fredrick Accum," C. A. Browne; "The Appeal of Science to the Community," Alexander Findlay; "A Century of Alkaloids," A. D. Thorburn; "The Antioch Plan of Cooperative Education as It Affects Students in Chemistry," C. S. Adams; "The Chemical Nature of the Colloidal Soil Material," P. L. Gile; "Summary of Records of Students' Work in Chemistry in Greeley High School, 1924-25," Frank S. Hannen.

Journal of Geography, for September, *2249 Calumet Ave., Chicago, $2.50 a year, 35 cents a copy.* "Objectives of Geography Instruction," W. R. McConnell; "The Pitch Lake, Trinidad," Preston E. James; "A Typical Farm in the Corn Belt: A Project," A. E. Shirling; "The Study of Economic Geography," Alton R. Hodgkins; "The Development of a World Port: Hampton Roads," Loulie C. Kelley.

Peabody Journal of Education, for September, *Nashville, Tenn., $2.00 a year, 40 cents a copy.* "Religion and the College," Ernest D. Burton; "The Pledge as an Instrument to Secure Honesty in Examinations," Lillian Doyle and Marie Foote; "The High-School Science Laboratory," Hanor A. Webb.

Popular Astronomy, for November, *Northfield, Minn., $4.00 a year, 40 cents a copy.* "The International Astronomical Union at Cambridge," E. W. Brown; "Occulation of Jupiter of 1925 December 17," William F. Rigge; "A New Piece of Demonstration Apparatus for Descriptive Astronomy Classes," Dinsmore Alter; "Report on Mars, No. 31," William H. Pickering; "American Astronomical Society, Thirty-fourth Meeting, Northfield, 1925."

School Review, for November, *University of Chicago Press, $2.50 a year, 30 cents a copy.* "Student Service in the High School," Dorothy M. Sass; "Enlarging the Horizon of High-School Pupils," E. Louise Noyes; "An Experiment in Teaching English Usage to Junior High School Pupils," Edith E. Shepherd; "The Metric System and the Public Schools," J. C. Jensen; "A Comparison of the Lecture-Demonstration and the Labora-

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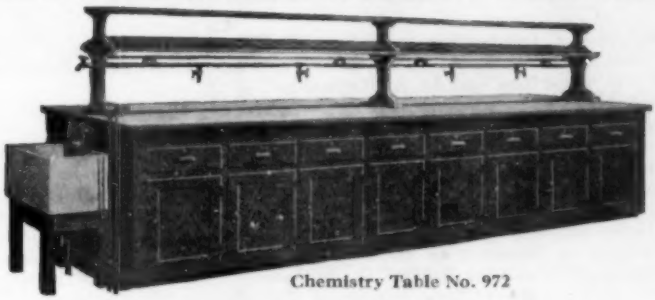

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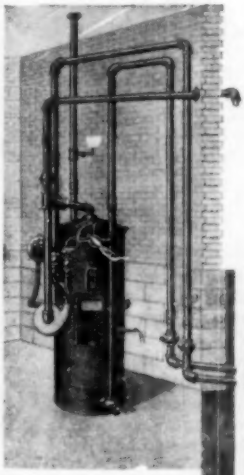

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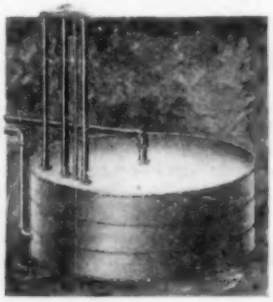

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tory Methods of Instruction in Science," Elliot R. Downing; "Some Experimental Comparisons of True-false Tests and Traditional Examinations," C. C. Crawford and D. A. Raynaldo.

Scientific Monthly, for November, *Garrison, N. Y., $5.00 a year, 50 cents a copy.*

RADIO TALKS ON SCIENCE: "The Atom," Dr. Paul D. Foote; "Carving the Scientific Possum," Ernest Merritt; "Meteors," Dr. George P. Merrill; "Highway Research," S. S. Steinberg; "Communism Among Insects," Dr. Thomas E. Snyder; "William Albert Locy," C. E. Tharaldsen; "New Light on the Physical Data of Language," Mark H. Liddell;

THE STATE OF SCIENCE IN 1924: "The Biological Action of Light," D. T. Harris; "Muscular Work," A. V. Hill; "The Energy of Expenditure," E. P. Cathcart; "Ice Ribbons," Dr. W. J. Humphreys; "The Figured Stones of Wurzburg," Dr. Leon Augustus Gausman; "Youthful Achievements of Great Scientists," George P. Meade; "Quacks and Quackeries," Dr. Heyward Gibbes.

Torreya, for September-October, 1925, *Lancaster, Pa., $1.00 a year, 30 cents a copy.* "Holly and Laurel," Elizabeth G. Britton; "Five New Species of Lobeliaceae," H. A. Gleason; "Some Extinct or Lost and Rediscovered Plants," P. A. Rydberg; "Demonstration of Protoplasmic Motion," Arthur P. Kelley; "Notes on Fagus Antipofii," T. D. A. Cockerell.

BOOKS RECEIVED.

High Lights in Geography, Europe, by David D. Cather and Katherine D. Cather. Pages xv+321. 14x20.50 cm. Cloth, 1925. Price $1.44. World Book Company, 2126 Prairie Avenue, Chicago, Illinois.

Every Day Problems in Science by John J. Pieper, University of Chicago High School, and Wilbur L. Beauchemp, School of Education, University of Chicago. Pages xxxiv+600. 14x19.50 cm. Cloth, 1925. Price $1.60. Scott, Forgman & Co., Publishers, Chicago.

Plain Geometry by F. Eugene Seymour, Professor of Mathematics, New York State Department of Education. Pages xv+333. 13x18.50 cm. Cloth, 1925. American Book Company, Chicago.

Elementary Principles of Physics by Robert W. Fuller, Raymond B. Brownlee and D. Lee Baker, Stuyvesant High School, New York City. Pages ix+859+13. 13.50x19 cm. Cloth, 1925. Allyn & Bacon, Chicago.

History of America by Carl R. Fish, University of Wisconsin. Pages 570+Li. 14x20 cm. Cloth, 1925. American Book Company, Chicago.

Webster's Secondary School Dictionary. Pages xxii+846. 16x22 cm. Cloth, 1925. American Book Co., Chicago.

Science and Theology by C. S. Gager. 87 Pages. 12.50x20 cm. Cloth, 1925. Open Court Publishing Company, New York and Chicago.

Art and Home Economics by Marian E. Clarke. Pages x+66. 14.50x21.50 cm. Cloth, 1925. University of Chicago Press.

The Teaching of Science and the Science Teacher by Herbert Brownell, Teachers College, University of Nebraska, and Frank B. Wade, Chemistry, Shortridge High School, Indianapolis, Indiana. Pages xi+322. 13.50x20.50 cm. Cloth, 1925. Price $2.00. The Century Company, New York City.

BOOK REVIEWS

The Teaching of Science And The Science Teacher by Herbert Brownell, Teachers' College, University of Nebraska, and Frank B. Wade, Chemistry Shortridge High School, Indianapolis, Ind. Pages xi+322. 13.50x20.50 cm. Cloth, 1925. Price $2.00. The Century Company, New York City.

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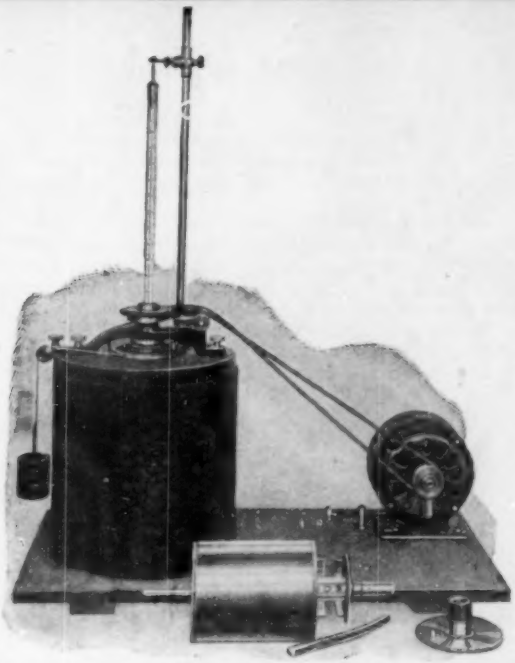

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C. H. S.

Science and Theology by C. S. Gager. 87 Pages. 12.50x20 cm. Cloth, 1925. Open Court Publishing Company, New York and Chicago.

The literature on the relationship between science and religion has been increased considerably by the recent controversy in Tennessee on the teaching of evolution. This book stands out as a clear cut explanation of the viewpoint of the modern biologist who has a deep religious sense. The author is Director of the New York Botanical Gardens and is a lecturer of some note. The substance of the book has been given many times in lectures. It is not controversial, but tells of the methods and mental attitudes of scientific men for the layman who is interested in modern thought along these lines.

The respective dommina of the theologian and the scientist are sharply defined. The persecution of those who believed in and practiced the scientific method of investigating natural phenomena as opposed to the authority of Aristotle and others is discussed. The distinction between the fact of evolution and the theories of the method is clearly made.

Any science teacher can profitably read this book, for while no new facts are presented, it will crystallize his ideas on this much discussed matter.

W. E. P.

"Every Day Problems in Science" by Charles John Pieper, Head of the Department of Natural Science, University of Chicago High School, and Wilbur Lee Beauchamp, Instructor in Natural Science, University of Chicago High School—Instructor in Education, College of Education, University of Chicago. 1st edition. Pages xxxiv+600. 14.5x19x3 cm. Cloth, 1925. $1.60. Scott-Foresman & Co., Chicago.

This new text in general science is different. It uses the inductive method of approach to the problems which it undertakes to solve, to a greater degree than most texts in general science. The pupil's experience is called upon first of all and then he is led to add to it and to try to understand what it is all about. Scientific principles are thus gradually brought out as their applications are studied. The book is the result of much "trying on the dog" and many mimeographed sheets have preceded it and paved the way. The subject matter is well selected from the standpoint of pupil experience and also in regard to difficulty. A teachers' Guide Book may be had to coach the beginning teacher as to the best method of use of the book. A unique feature of the preface is a section addressed to the pupil on "How to Study this Book." The many illustrations are an attractive feature of the book and they will greatly aid the student through the visual education that they afford. A pronunciation list in the back of the book makes easy the learning of new technical words. Given a teacher who is something of a real scientist and the pupils who study this book should make a good start toward an understanding of some of the simpler parts of their scientific surroundings and, better yet, they should get a vision of the scientific method of attack on problems. All general science teachers should ask to see this new text.

T. B. W.